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The Engineer

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PUBLIC NOTICES

Air Ministry.
DIRECTORATE OF TECHNICAL DEVELOPMENT.

DRAUGHTSMEN are REQUIRED at the Royal Aircraft Establishment, South Farnborough, Hants, as follows:—

Ref. No. A. 418/9.—TWO DRAUGHTSMEN, GRADE II.—One for work in connection with Aero-engines and General Mechanical Work; candidates should have had a good technical training and works experience and some drawing-office experience in connection with high-speed internal combustion engines or allied mechanical work. One for Technical Publications Work; candidates for this post should have good general knowledge of aircraft and aero-engines, ability to prepare perspective sketches suitable for reproduction in technical handbooks and to build up perspective illustrations from workshop drawings.

Starting salary £125 plus Civil Service bonus per annum, giving a present total remuneration of £199 16s. per annum on the scale £125-£7 10s.-£150 plus bonus per annum.

Ref. No. A. 387/420.—FOUR DRAUGHTSMEN, GRADE III.—One for detail work in connection with the design of Small Mechanical Apparatus, such as recording and indicating instruments; three for work in connection with Aircraft and Engines. Candidates should have had good technical education and works experience; actual drawing-office experience not essential.

Salary 40s. to 52s. plus Civil Service bonus per week (present total equivalent £3 6s. 2d. to £4 2s.), starting salary depending on experience.

Preference given, other things being equal, to ex-Service men.

Apply (quoting appropriate reference number), stating age and full particulars of training and experience, to the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants. 4776

Civil Service Commission.

The Home Office announces 22 VACANCIES for INSPECTORS of FACTORIES, Class II. (Men or Women). Salary £200, rising by £15 a year to £350, with usual Civil Service bonus in addition. The initial salary plus bonus at present rates would amount to £299. The appointments carry prospect of promotion to the higher grades.

A competition for these vacancies is about to be held by the Civil Service Commissioners, in consultation with the Home Office. A few additional vacancies may arise later and may be filled from among the candidates.

Candidates must be over 23 and under 32 years of age on 1st May, 1930, but applications from candidates over 32 with exceptional qualifications will be considered.

The Regulations for the competition and forms of application may be obtained from the INDUSTRIAL DIVISION, Home Office, London, S.W.1. The last date for submitting applications is 1st May. 4740

Crown Agents for the Colonies.
COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POSTS:—

M/2095.—ASSISTANT TOWN PLANNING OFFICER REQUIRED by the LAGOS EXECUTIVE DEVELOPMENT BOARD for two tours of 12 to 18 months' service, with possible extension. Salary £480, rising to £720 a year by annual increments of £30 and thence rising to £920 a year by annual increments of £40. Seniority pay of £72 a year on reaching salary of £720 a year. (The question of paying a higher commencing salary than the minimum of the foregoing scale will be considered in the case of the selection of a very highly qualified officer.) Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, 24 to 30 years of age, should hold the Diploma of the Town Planning Institute of Great Britain or such other Degree or Diploma recognised as its equivalent. Must have had good theoretical training in town planning at a University or School recognised by the Town Planning Institute of Great Britain. Should have had practical experience in the preparation of statutory municipal town planning schemes and re-planning schemes for existing areas. Should have a knowledge of the law in relation to town planning practice.

M/1990.—ASSISTANT ENGINEERS REQUIRED for the PUBLIC WORKS DEPARTMENT of the FEDERATED MALAY STATES for four years' service, after which, subject to satisfactory service, the officers appointed will be eligible for confirmation in the permanent and pensionable establishment. It is probable that the number of permanent appointments will be sufficient for those officers whose services have been entirely satisfactory, but no guarantee can be given. If at the end of four years' service an officer's services have been entirely satisfactory and he is not offered or declines further employment, he will be paid a bonus of 2850 dollars. Salary 400 dollars a month, rising to 800 dollars by annual increments of 25 dollars, plus a temporary non-pensionable allowance of 10 per cent. for bachelors and 20 per cent. for married men. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. No income tax at present imposed by the Federated Malay States Government. Free passages provided. Candidates, age 23 to 26, must have received a good theoretical training, preferably at a University or College recognised by the Institution of Civil Engineers and possess a Civil Engineering Degree or obtain such other Diploma or Distinction in Engineering as the Secretary of State may decide in any particular case or have completed articles with a Civil Engineer of good standing, and have passed Sections A and B of the examinations for Associate Membership of the Institution of Civil Engineers. In addition, candidates must have had at least one year's practical experience of Civil Engineering under a qualified civil engineer.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting the reference number against the appointment for which application is made. 4782

Ministry of Transport.
ROADS DEPARTMENT.

APPLICATIONS are INVITED for an APPOINTMENT as UNESTABLISHED CIVIL ENGINEERING DRAUGHTSMAN in the Roads Department of the Ministry of Transport at Whitehall, at a commencing wage of £3 per week.

Applications should be made immediately in writing to the ESTABLISHMENT OFFICER, Ministry of Transport, 6, Whitehall-gardens, S.W.1, stating age, qualifications, experience, and references. 4766

Royal Air Force Educational Service.

APPLICATIONS are INVITED for a few VACANCIES as CIVILIAN EDUCATION OFFICERS in the Royal Air Force Educational Service. It is expected that these vacancies will have to be filled in September next. Candidates should have a good Degree in Engineering, Physics, or Mathematics. Other things being equal, preference will be given to ex-Service candidates, and those with previous teaching experience.

The appointments will be made to Grade III., the scale of salary of which is £234-£15-£480, with an allowance varying from £60 to £100 per annum, according to the position on the scale. For entrants with appropriate previous experience commencing salaries up to ten increments above the minimum of the scale may be allowed. Promotion to appointments in higher grade is by selection.

The form of application and a copy of the regulations for the Educational Service may be obtained from the SECRETARY, Air Ministry, Gwydyr House, Whitehall, S.W.1. Applications should be returned not later than 22nd April, 1930. 4677

Technical Assistants.
FIVE MECHANICAL ENGINEERS (unpensionable). Salary £175 to £275 per annum, according to qualifications, plus variable bonus (present total about £266 to £392). Must be British subjects. Age 24½-27 years. Preference and age concession to ex-Service men. Degree or equivalent examination certificates; and suitable workshop training, essential.

Application forms, returnable by 14th April, 1930, from CHIEF SUPERINTENDENT OF ORDNANCE FACTORIES, Royal Arsenal, Woolwich, S.E.18. 4741

University of Liverpool.
FACULTY OF ENGINEERING.

DEAN: Professor G. E. SCHOLES, M.B.E., M.Sc., M.I.A.E., M.I. Mech. E.

Prospectus and full particulars may be obtained on application to the REGISTRAR of Courses designed for Students desiring to qualify as Mechanical, Electrical, Civil or Marine Engineers, as Naval Architects or as Metallurgists and Metallurgical Engineers. 4743

Armstrong College.
NEWCASTLE-UPON-TYNE.
(IN THE UNIVERSITY OF DURHAM.)

COURSES for the PASS DEGREE of B.Sc. and the HONOURS DEGREE of B.Sc. in MECHANICAL, MARINE, CIVIL or ELECTRICAL ENGINEERING, MINING, METALLURGY, or NAVAL ARCHITECTURE. The curricula of the Pass Degree and the Honours Degree normally occupy periods of three and four years respectively, but candidates presenting evidence of sufficient previous training may be allowed to proceed to either Degree after two years' residence.

The engineering laboratories have recently been extended, and all Departments are equipped for advanced tutorial and research work.

Full particulars of the Courses may be had on application to

THE REGISTRAR,
Armstrong College,
4056 Newcastle-upon-Tyne.

Sunderland Education Committee.
SUNDERLAND TECHNICAL COLLEGE.
DEPARTMENT OF MECHANICAL AND CIVIL ENGINEERING.

APPLICATIONS are INVITED for the POST of FULL-TIME LECTURER in ENGINEERING. Candidates should possess an Honours Degree in Engineering, or its equivalent, and must have had Works or Drawing Office experience.

Salary in accordance with the Burnham Award.

Forms of application may be obtained from the Principal, the Technical College, and must be returned to the undersigned on or before Monday, 5th May, 1930, by first post.

HERBERT REED,
Chief Education Officer.
Education Offices,
15, John-street, Sunderland,
24th March, 1930. 4683

PUBLIC NOTICES

The University of Sheffield.

A RESEARCH ASSISTANT is REQUIRED in the Mechanical Engineering Department, to work under the direction of Professor F. C. Lea. Salary £400 per annum.

Application should be made, on or before April 23rd, to the undersigned, from whom further particulars may be obtained.

W. M. GIBBONS,
4760 Registrar.

PATENTS AND DESIGNS ACTS, 1907 TO 1928

Notice is Hereby Given that

SOCIETE ANONYME DES ETABLISSEMENTS NEU, of 47, Rue Fourier, Lille, France, SEEK LEAVE to AMEND the SPECIFICATION of LETTERS PATENT No. 303,489 granted to them for an invention entitled "Improved Method of and Means for the Cleaning or Sweeping, by Blowers, of Steam Generators, Superheaters, Water Heaters, Air Heaters, or the like."

Particulars of the proposed Amendment were set forth in No. 2149 of the "Illustrated Official Journal (Patents)," published on the 26th March, 1930.

Any person, or persons, may give Notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton-buildings, London, W.C. 2, within one calendar month from the date of publication of the said Journal.

W. S. JARRATT,
P6863 Comptroller-General.

City and Royal Burgh of Dundee—Electricity Department.

The Corporation invites TENDERS for the CONSTRUCTION of a REINFORCED CONCRETE PUMP CHAMBER in the River Tay under the Eastern Wharf, together with the CONSTRUCTION of a REINFORCED CONCRETE PILED FOUNDATION for Circulating Water Pipe, approximately 515ft. long, at Carolina Port, Dundee.

Specification, schedule of quantities, form of Tender and general conditions of contract and drawings may be obtained from the undersigned on payment of a deposit of £2 2s., which sum will be returned upon receipt of a bona fide Tender.

Tenders (sealed in envelopes provided) must be lodged with W. H. Blyth Martin, Esq., Town Clerk, City Chambers, Dundee, not later than by Saturday, 10th May, 1930.

The Corporation does not bind itself to accept the lowest or any Tender.

D. H. BISHOP, B.Sc., M.I.E.E.,
General Manager and Engineer.
Electricity Supply Department,
Dudhope Crescent-road, Dundee,
28th March, 1930. 4753

Metropolitan Water Board.
TENDERS FOR THE SUPPLY OF STORES, &c.

The Metropolitan Water Board invite TENDERS for the SUPPLY of the undermentioned STORES and SERVICES, &c., for the period of 12 months, commencing 1st June, 1930:—

Tender No.
1. Bricks, Fire-bricks, Cement, &c.
8. Iron and Steel.
9. Bolts and Nuts Screws, Files, Shovels, Steam Tubes, &c.
12. Fuel Oil, Oils (Lubricating), Kerosene, Motor Spirit, Greases, Tallow, &c.
19. Iron, Brass, Gun-metal and other Castings.
20. G.M. Stop Cocks and Ferrules, Outlets and Caps for Fire Hydrants.
22. Timber.
23. Maintenance of Weighing Machines.

Tenders must be submitted on the official forms, which may be obtained from the Chief Engineer, by personal application at the Offices of the Board (Room 156) or upon forwarding a stamped addressed sack envelope.

Applicants should refer to the number of the Tender for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board" and endorsed in the manner indicated in the form of Tender, must be delivered at the Offices of the Board (Room 122) not later than 11 a.m. on Thursday, 24th April, 1930.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
173, Rosebery-avenue, E.C. 1,
24th March, 1930. 4699

The Madras and Southern Mahratta Railway Company, Limited, invite TENDERS for:—

MATERIAL for CONVERSION of 4-6-0 and 4-8-0 TYPE (METRE GAUGE) LOCOMOTIVES to SUPERHEAT.

Tenders are due in on Tuesday, 29th April, 1930, by 2 p.m. Tender form obtainable at address below, fee One Guinea, which is not returnable.

The Directors do not bind themselves to accept the lowest or any Tender.

Company's Offices: 25, Buckingham Palace-road, Westminster, S.W.1. 4775

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PUBLIC NOTICES

Corporation of Harwich.

FACTORY SITES.

The Corporation invite FIRMS contemplating opening new works to CONSIDER SITES which this Corporation are prepared to SELL or LET on long lease.

Excellent harbour facilities.

Firms interested should communicate with the BOROUGH ENGINEER and SURVEYOR, Harwich. 4746

South Indian Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY of—

1. RAILWAY TICKETS.
2. SPARE PARTS of LOCO. ENGINES (Engine Frame Plates).
3. MISCELLANEOUS ARTICLES AND MATERIALS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked: "Tender for Railway Tickets," or as the case may be, with the name of the firm tendering, must be left with the undersigned not later than Twelve Noon on Friday, the 25th April, 1930.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the Specification No. 1 and of 5s. for each copy of Specifications Nos. 2 and 3.

Copies of drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France,
Westminster, S.W. 1.
2nd April, 1930. 4786

Aldershot Gas, Water and Electricity Co.

DISTRICT LIGHTING COMPANY.
TECHNICAL ASSISTANT.

APPLICATIONS are INVITED from fully qualified young men for the POSITION of TECHNICAL ASSISTANT to the Chief Engineer.

Age should not exceed 25 years, and preference will be given to candidates who have been admitted by examination to the Institution of Civil Engineers.

Apply in the first instance, in own handwriting, giving full particulars of qualifications, training, drawing-office experience, &c., and stating salary required, together with copies of three recent testimonials, to the undersigned, on or before 14th April, 1930.

By Order,
F. A. RICKETTS,
Secretary.

Chief Office,
Victoria-road, Aldershot. 4757

Civil Engineer.

APPLICATIONS are INVITED for the POSITION of ENGINEER-IN-CHIEF of the Lower Liao River Conservancy Works, Newchwang, North China.

Salary offered is Mex. dollars 1150 per month (present exchange 1s. 5d.), with medical attendance and house allowance. Travelling expenses (1st class) from place of engagement and return thereto on expiration of term of service.

Appointment, in the first instance, to be for two years from 1st July, 1930, or earlier if possible.

The undertakings comprise harbour and conservancy works on the lower reaches of the Liao River and the dredging of a channel across the bar.

Preference will be given to civil engineers who have had previous experience in connection with harbour works and the control of suction dredgers.

Apply in writing, before 15th April, 1930, to

THE SECRETARY,
Chinese Maritime Customs,
P6860 26, Old Queen-street, Westminster.

PUBLIC NOTICES

Administrative County of London.

APPOINTMENT OF CHIEF ENGINEER AND COUNTY SURVEYOR.

The London County Council invites APPLICATIONS for the APPOINTMENT of CHIEF ENGINEER and COUNTY SURVEYOR at a fixed salary of £3000 a year.

The successful candidate will hold office during the pleasure of the Council and will be required to give his whole time to the duties of his office. Any fees received by him, either as a witness or in any other capacity, must be paid to the Council. He will not on retirement be entitled to any pension under the Superannuation (Metropolis) Act, 1866, but will be subject to the Council's regulations in respect of the Superannuation and Provident Fund.

Applicants must either have served with H.M. Armed Forces during the war or must be natural-born or naturalised British subjects. Due weight will be given to the claims of those applicants who served or attempted to serve with H.M. Forces during the war.

Applications must be on the official forms, which can be obtained from the Clerk of the Council, The County Hall, Westminster Bridge, S.E. 1. The form contains particulars as to the duties and conditions attaching to the appointment.

The latest date for receiving applications is 23rd May, 1930. Canvassing disqualifies.

MONTAGU H. COX,
Clerk of the London County Council.

The County Hall,
Westminster Bridge, S.E. 1,
31st March, 1930. 4773

Municipal Corporation of Rangoon, Burma.

APPOINTMENT OF EXECUTIVE ENGINEER.

APPLICATIONS are INVITED for a POST of EXECUTIVE ENGINEER, to be under the Chief Engineer of the Corporation of Rangoon.

AGE.—Preferably between 35 and 40.

QUALIFICATIONS.—Candidates must be Members or Associate Members of the Institution of Civil Engineers or hold the Testamur of the Institution of Municipal and County Engineers or other equivalent qualifications.

EXPERIENCE.—Candidates should have previous municipal experience, especially in connection with the control and administration of large water supply and sewerage systems.

SALARY.—Rs. 1200 for the first year, rising by annual increments of Rs. 100 to Rs. 1700 per month, plus an overseas allowance of Rs. 150 per month and a motor car allowance. The Officer appointed will be eligible to subscribe to the Municipal Provident Fund if he elects to become a subscriber. Subscriptions are payable at the rate of one-twelfth of salary, and an equal amount is contributed by the Municipal Corporation. No exchange compensation will be allowed.

The appointment will be on agreement for a period of five years, subject to a probationary period of one year. A free first-class passage to Rangoon will be provided and leave and leave allowances will be in accordance with the Fundamental Rules applicable to Officers in superior service under the Government of India.

Further particulars may be obtained from the undersigned by forwarding an addressed envelope to them and by whom applications will be received up to the 30th April, 1930.

OGILVY GILLANDERS & CO.
(Reference R3138).
4767 32, Old Jewry, London, E.C. 2.

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, for PERMANENT POSITION, with good prospects, ENGINEER for Selling Heavy Plant. Requirements, British Subject, fluent French and/or German. Age not over 32. To travel part time throughout Europe. Only those with above qualifications need apply.—Address, stating age, education, qualifications and experience, 4687, The Engineer Office. 4687 A

PUBLIC NOTICES

County Borough of Blackpool.

CLEANSING DEPARTMENT.

APPLICATIONS are INVITED for the POSITION of ENGINEER and REFUSE DISPOSAL WORKS MANAGER.

It is essential that applicants must have had a sound technical and practical training as a Works Engineer; capable of supervising the construction of plant and buildings, a good organiser, and have a knowledge of workshop costing.

The commencing salary will be £250 per annum, rising by annual increments to a maximum of £290, together with house.

The appointment will be subject to the provisions of the Council's Superannuation Scheme, and the successful candidate will be required to pass a medical examination.

Age must not exceed 45 years.

Applications, on forms to be obtained from the undersigned, and accompanied by copies of three recent testimonials, to be delivered to me not later than Monday, 21st April, 1930.

H. ARDERN,
Director.

Cleansing Department Offices,
Sefton street,
2nd April, 1930. 4781

SITUATIONS OPEN (continued)

WANTED, a Thoroughly Practical, Capable MECHANICAL ENGINEER, with good all-round knowledge of General Engineering and with some knowledge of Boiler and Tank Work, as FOREMAN for a works in East London.

Must be capable of handling workmen and obtaining good results at a reasonable cost.—Address, with full particulars of experience, references, salary required, P6874, The Engineer Office, P6874 A

WANTED, ASSISTANT MECHANICAL ENGINEER for South Wales Collieries.—Write, stating experience and salary required, to Z.H. 724, c.o. Deacon's Advertising Agency, Fenchurch-avenue, London. 4788 A

WANTED, ASSISTANT SUPERINTENDENT for large works engaged on mass production of Light Cast Iron and Steel Parts. Applicants must have executive experience and a good knowledge of the design and methods of manufacturing Limit Gauges to control machining operations on such parts. Please state age and give full particulars of experience.—Address reply, 4744, The Engineer Office. 4744 A

A FIRM of High-class Machine Tool Makers are prepared to RECEIVE APPLICATIONS for POSITION of TECHNICAL REPRESENTATIVE.—Address, stating age, experience, and terms, 4758, The Engineer Office. 4758 A

CHARTERED CIVIL ENGINEER, Specialist in Reinforced Concrete, has VACANCY in his office for PREMIUM PUPIL.—Address, P6872, The Engineer Office. P6872 A

CONSTRUCTIONAL STEEL WORK.—Well-known North Country FIRM of Constructional Engineers REQUIRE the SERVICES of a REPRESENTATIVE for London and Home Counties. Applicants must be conversant with the trade and hold a connection amongst architects and engineers. Position is progressive for the right man.

Address, giving full particulars of age, past experience, and salary required, P6870, The Engineer Office. P6870 A

ENGINEER REQUIRED for Spinning and Weaving Factory in Southern India. Three-year contract. Applicants must have good education, thorough engineering training, including Steam Raising, Steam Engines, Diesel Engines, Mill and General Engineering. Preference given to one with Spinning and Weaving experience.—Address, giving full particulars, P6859, The Engineer Office. P6859 A

SITUATIONS OPEN (continued)

FIRST-CLASS DESIGNERS REQUIRED for Light Mechanical Work at engineering works situated in South-East London area.—Address, giving full particulars of experience, age, and salary required, 4742, The Engineer Office. 4742 A

MECHANICAL ENGINEER AND DESIGNER REQUIRED by company of Fan Manufacturers. Applicants should have B.Sc. (Eng.) and A.M.I. Mech. E., and possess several years' responsible experience in Mechanical Engineering Practice as well as specialised experience in Fan Engineering in all its applications. The successful candidate will be required to take full responsibility for the design and lay-out of the company's products and will be immediately responsible to the Technical Director. Only high-grade men of energy, foresight and initiative, with a desire to get out of the rut are invited to apply.

Applications, which will be treated confidentially, should contain the fullest particulars, references and salary required, and should be addressed—
4790, The Engineer Office. 4790 A

LARGE Manufacturing and Sales Organisation has VACANCY for a Successful SALESMAN with sound Engineering knowledge. Must have first-class credentials, education, appearance, and possess executive capabilities. Own car essential. Excellent prospects for the right type. Send full particulars, which will be considered confidential.—Address, 4777, The Engineer Office. 4777 A

HEATING ENGINEERS WANTED, Capable of designing and superintending the installation of Hot Water and Steam Heating Plants on all modern systems.

Applications, stating age, experience, and salary required, to the MANAGING DIRECTOR, Musgrave and Co., Ltd., St. Ann's Ironworks, Belfast. 4768 A

LONDON CONSTRUCTIONAL ENGINEERS REQUIRE SERVICES of DESIGNER for Steel-framed Buildings and Theatres, with experience of these classes of work and conversant with L.C.C. requirements. Full particulars in confidence.—Address, 4784, The Engineer Office. 4784 A

SALES ENGINEER for Conveying and Elevating Plant and General Mechanical Handling Equipment, technically trained in mechanics and structures, public school preferred, possessing energy, initiative and character. Fullest details, including age and present salary, should accompany application, also stating any previous associations with gas and electrical undertakings or other industrial concerns.—Address, 4763, The Engineer Office. 4763 A

SALES ENGINEER, to Take Charge of Branch Office, South Midlands. Must have held similar position. Knowledge of pumps essential.—Address, stating education, age, qualifications, and salary required, &c., P6857, The Engineer Office. P6857 A

SEVERAL FIRST-CLASS ENGINEERS REQUIRED for training as Technical Advisors on the Sales Side in connection with Combustion Problems in various industries. The posts will be in Australia and the Far East. Engineering Degree essential, with at least three years' workshop and drawing-office experience. Commencing salary according to qualifications, £450 to £650 per annum. First-class passage out and £50 kit allowance. Age not over 32.—Address, 4780, The Engineer Office. 4780 A

WANTED, LEADING DRAUGHTSMAN for High-speed Compressorless Diesel Four-cycle Engine design; capable of developing Vertical Engines for 30 B.H.P. units and upwards in multi-cylinders for industrial and electrical purposes.—Apply, stating age, experience, and salary required, to MARSHALLS, Engineers, Gainsborough. 4761 A

For continuation of Small Advertisements see page 4.

BY ORDER OF THE RECEIVER STEPHEN P. CHILD, ESQ., F.C.A.

AC (ACEDES) CARS, LTD.,

THAMES DITTON, SURREY

within a few minutes' walk of Thames Ditton Station (Southern Railway)

EXTENSIVE FREEHOLD and LEASEHOLD

MANUFACTURING PREMISES

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The premises are mostly of one storey and contain a FLOOR AREA of about 145,000 SQUARE FEET.

VALUABLE STOCK OF SPARE PARTS

NECESSARY IN THE MANUFACTURE OF A-C CARS, also GOODWILL, PATENTS, &c.

THE HIGH-CLASS MODERN MACHINE TOOLS, ENGINEERING PLANT and EQUIPMENT

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30 Plain, Universal, Vertical and Horizontal Milling Machines, by Cincinnati, Browne and Sharpe, Garvin, Milwaukee, and others.
50 Capstan, Turret and other Lathes, by Potter and Johnson, Gridley, Cleveland, Browne and Sharpe, &c.
37 Centre All geared and Gap Lathes, 6in. to 14in., by La Pointe-Walcott, Hendy, Herbert, Pratt and Whitney, and others.
Herbert Combination Turret Lathes and Automatics.
35 Universal, Plain and Internal Grinders, by Churchill, Le Blond, Herbert, Browne and Sharpe, Heald, Landis, &c.
60 Radial, Pillar, Sensitive and Multiple-spindle Drilling Machines, by Herbert, Archdale, Tullis, &c.
14 Gear Cutters and Shapers, by Fellowes and others.
Horizontal and Vertical Boring Machines, by Dickinson and Garvin.
Fischer Oil Grooving Machine.
Gleason Bevel Gear Generating Machine.
11 Planing, Broaching and Slotting Machines, by La Pointe, Butler, and others.
Twin-spindle Profiling Machine, by Pratt and Whitney.
Woodworking Machinery, including **Saw Benches, Band Saws, Spindle Moulders, Planing, Thicknessing, and Tenoning Machines.**
Brinell Tester, Dynamometer, by Heenan and Froude. **Norton Crank Balancing Machine.**
Power Presses, 112-Cell Storage Battery Set, Hardening and other Furnaces.
30 Electric Motors, 1–50 H.P., 440 volts D.C. **Generators,** 150–30 kW, 440 volts D.C.
Large quantity of **Small Tools, Drills, Milling Cutters, Reamers, Gauges, &c.**
Crossley Suction Gas Plant and Engine. Tangye Suction Gas Plant and Engine.
Several Tons of **High-speed and other Bar Steel, Belting, Shafting, Plummer Blocks, &c.**
Laboratory Apparatus, Weighing Machines, Gantry Cranes, Office Furniture, Typewriters, Time Recorders, and miscellaneous items.

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A Seven-Day Journal

Proposed Electrification on the London and North-Eastern Railway.

THE consideration by a Select Committee of the House of Commons of the Bill promoted by the London Electric Railways Company for the extension of the Great Northern, Piccadilly and Brompton Railway—generally known as the Piccadilly Tube—brought out on Friday last, March 28th, the proposals of the London and North-Eastern Railway Company, which is opposing the Bill, for the electrification of that company's lines in what may be called the London area. The offers of grants in aid have led to the London Electric Railways proceeding with the idea—previously proposed in 1929—of an extension from Finsbury Park, but instead of going only to Wood Green or Southgate, as originally intended, the company seeks powers to build a line, 7½ miles long, or thrice the length, to Cockfosters. Sir Ralph Wedgwood told the Select Committee last Friday that his company had a scheme for electrifying the Great Northern main line as far as Welwyn and the old Great Northern branch suburban lines, covering 60 route miles. The estimated cost was £3,700,000, with an addition of £650,000 for the widening of tunnels. Practically all the money would be spent on works, so that it was clearly a scheme which would provide employment, and therefore might receive Government assistance. The company had decided that the electrification should be undertaken on condition that an adequate grant was obtained from the Government and that satisfactory terms could be arranged for terminal accommodation in the City. In his view, that scheme would provide adequately for the needs of the district, having regard to economic considerations. His company could electrify 60 miles of railway at a cost of £4,350,000, whereas the new line, only 7½ miles long, proposed in the Bill, was estimated to cost £5,650,000. On Tuesday the Committee found the preamble of the Bill proved so far as the extension to Cockfosters was concerned.

The French Navy.

THE ideas of France with regard to naval policy appear to have been summed up in the debate on the naval credits in the Senate. Little importance was attached to the German efforts to combine the maximum armament and speed within the 10,000-ton limit on the ground that Germany is not in a position at the moment to continue the construction of such costly ships, while, in any event, the danger from them, according to the French, is minimised by the submarine. Nevertheless, it was declared that France has prepared the plans of a new type of ship that may counter the German battle-cruiser, but that nothing will be done with it until the result of the London Conference is known. All other considerations of strategy are subordinated to the necessity for keeping the route open between France and the North African Colonies. This consideration is the basis of French naval policy which makes an acceptance of parity with Italy impossible, and the increase of the Italian programme of naval construction is regarded as eliminating all chance of France's reducing her own. What the French particularly regard as disquieting is the character of the new Italian Navy, consisting as it does mainly of light and rapid cruisers and destroyers, and a strong air force that can obviously have no effective range beyond the Mediterranean. In the opinion of the French, the security of the African Colonies cannot be ensured by parity with Italy. Still, there is a limit beyond which some continental countries will find it difficult to go in the way of naval construction. France needs a minimum effective *personnel* of 53,000 men, and it is not easy to find it, despite the special advantages offered.

Power for the Underground Railways.

To mark the developments which have taken place during the quarter of a century that has passed since their Lots-road power station was first put into commission, the Underground Railway Companies last week extended an invitation to members of the Press to inspect the work accomplished and in progress. At the time of its construction the station was accounted modern, its eight 6000-kW turbo-generators being then the largest in the world, and its sixty-four boilers, arranged on two floors, being equally impressive in their way. The original turbines have long since gone to make room for more efficient machines, and when the present programme is completed the turbine room will be occupied by nine units of 15,000-kW each. The new machines, of which six are now in service, and a seventh is in course of erection, have all been constructed by C. A. Parsons and Co., Ltd. The boiler pressure of the station is also being raised from the original figure of 200 lb. at 500 deg. Fah. to the still very moderate pressure of 290 lb. at 700 deg. Fah., eight new marine type Babcock and Wilcox boilers, of 50,000 lb. capacity, built for the higher pressure, being now in service and another eight under erection, in addition to four similar units put down temporarily to facilitate the work of reconstruction. The original boilers were of the land type, with a capacity of only 16,000 lb. of steam per hour. A water sluicing system has also been installed for the removal of ashes. The present output of the station is at the rate of about 380 million units per annum, with a maximum load of about 92,000 kW. The thermal efficiency of the whole station is about 16·25 per cent., but the segregated figure for the first two generators and their boilers working at the higher pressure is no less than 22 per cent., the calculation being made on a week's running with a 60 per cent. load factor.

Television.

FOR some months past television broadcasts have been conducted by the Baird International Television Company, Ltd., and on Monday last sights and sounds were simultaneously broadcast from the company's offices in Long-acre. The speech and image currents were conveyed by wire to Savoy-hill, and then to the B.B.C. London Regional and National transmitters at Brookman's Park. Those who witnessed the demonstration gathered at the Baird laboratories at Hendon, where they saw the faces of the speakers and singers, in addition to hearing their voices reproduced on a large moving coil loud speaker. The company did not use one of the home receiving sets it has recently placed on the market, but we understand that the results obtained with these sets equal those given by the type of apparatus that was employed. While it was quite easy to recognise the faces of prominent people who were taking part in the proceedings at Long-acre, and whilst the voices were perfectly synchronised with the movement of the lips, the demonstration showed that television is still not perfect. Not much improvement has been made in the performance of the apparatus since we saw it in operation about two years ago. The images, which are quite small, still have a flicker and jerkiness, similar to that of the early cinematograph. From a scientific point of view, the invention is, however, of great interest, and many experimenters will no doubt welcome the simultaneous transmission of moving images and speech. It remains to be seen, however, whether television in its present stage of development will prove attractive as a form of entertainment, which, of course, is what the general public expects of it. Great credit is, nevertheless, due to Mr. Baird for his perseverance.

A Standard Basis of Charges for Gas.

TUESDAY, April 1st, of the present week was noteworthy as being the day appointed under the Gas Undertakings Acts of 1920 and 1929 for the final completion of the alteration in the basis of gas charges, which began ten years ago with the passing of the Gas Regulation Act. From that date the basis of charge will be the quantity of heat units, and not the volume of gas supplied, for all statutory authorities, with the exception of small village undertakings which may charge as before until they develop. The substitution of the therm, or 100,000 British thermal units for the cubic foot, has enabled gas undertakings to produce gas in the manner which local conditions render most economical and economy in production has thereby been achieved. The use of the therm as a unit also enables a ready comparison to be made between the heating value of solid liquid and gaseous fuels and other sources of heat. Now that a uniform scientific basis for charging has been universally adopted, the way is open for further developments in the gas industry. The National Fuel and Power Committee has reported in favour of certain changes, which include the removal by parliamentary action of certain obsolete enactments which prevent gas companies from developing the industry along modern commercial lines. It is worthy of note that although electricity undertakings are allowed to offer two-part and other special tariffs, and that although similar principles are used as the basis of telephone charges, it is not legally possible at present for the gas undertakings to introduce similar methods of charging.

British Canal Developments.

AT the annual meeting of the proprietors of the Grand Junction Canal Company, which was held in London last week, Mr. H. H. Curtis, the chairman of the company, made some interesting references to the first year's working of the company. As an instance of the advantages of the unification of the five companies which had formerly owned the 240 miles of canal between Regent's Canal Dock at Limehouse and Birmingham, Mr. Curtis mentioned that whereas in 1921 the sum of £10,924 had been spent on pumping, only £5334 had been spent last year, which was a much drier year than 1921. By installing powerful flood lamps at Regent's Canal Dock, Limehouse, the company had now made it possible to deal with traffic from the Thames to the Grand Junction Canal by night as well as by day. Ships carrying coal for London's gas and electricity undertakings could now be discharged and the coal transferred to barges, no matter at what time they arrived. All the new barges on the Regent's Canal section were, Mr. Curtis said, to be designed to carry 100 tons, while on the Warwick section of the Canal system it was proposed to enlarge the locks so that these new barges could be dealt with. This matter was still being considered by the Government, as was also a scheme for the improvement of the 240 miles of canal between London and Birmingham, so that the waterway would be made suitable throughout its whole length for the passage of up-to-date mechanically-propelled boats. Such a development would, Mr. Curtis pointed out, need wider and deeper canals, with banks specially protected against possible danger by the faster craft, and the decision of the Government with regard to this development scheme was now awaited.

The New Antwerp-Liege Canal.

THE Belgian Government has decided that the construction of the new and important canal between Antwerp and Liége shall be commenced early next month, the first sod being cut ceremoniously by the King at Vronhoven, on the border of the provinces of Limbourg and Liége. The canal will give Liége and its hinterland access to the port of Antwerp through entirely Belgian territory, and will favour Antwerp at the expense of the rival Dutch port of Rotterdam. It is to be navigable for vessels of at least 1350 and possibly 2000 tons, and will have a length of something like 70 miles. The construction of such a canal through a densely populated country already served by more railways per square mile than any other country in the world is evidence of the faith of the continental nations in the advantages of water transport. Water will be supplied by the Meuse, and on account of the great variation in the flow of that river, a regulating reservoir will be constructed by damming the Ourthe and Amblève, tributaries of the Meuse, in the Ardennes. The question of the water supply is a thorny one, as the Meuse is an international navigable river, and the Dutch may not view with equanimity the diversion of some of its water, even from a point at which the river is wholly in Belgian territory.

The Late Professor J. O. Arnold.

IT is with great regret that we have to record the death of Professor John Oliver Arnold, Emeritus Professor of Metallurgy in the University of Sheffield. Professor Arnold, who died at Oxford on Thursday of last week, March 27th, was born at Peterborough in 1858 and was educated at King Edward's School, Birmingham, and on the Cadet School ship "Conway." After a voyage to India he entered the engineering department of the Sheffield Steel and Ironworks, and subsequently held several appointments in laboratory and testing departments at Sheffield works. In 1889 he was appointed Professor of Metallurgy at the Sheffield Technical School and remained a member of the staff when the school was absorbed in the University. He designed the metallurgical laboratories and steel works at the University of Sheffield, and was the head of the metallurgical department of the University from its opening until he resigned his professorship in 1920. He was a pioneer worker in the discovery of the influence of vanadium on steel, and in his later work he was able, by substituting molybdenum for tungsten, to produce a high-speed steel with remarkably good characteristics. He contributed many papers on the chemical constitution of steel and its uses in industry, which are to be found in the "Transactions" of the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Architects, and the Iron and Steel Institute. Professor Arnold was a Past-President of the Sheffield Society of Engineers and Metallurgists, and was elected a Fellow of the Royal Society in 1912. He was a member of the Standing Committee on Metallurgy of the Advisory Committee to the Privy Council, and was frequently consulted by the Admiralty on matters relating to materials for naval construction. His most important published work was "Steel Works Analysis," which is regarded as a standard treatise on the subject.

The New G.W.R. Station at Bristol.

WORK has now been begun on the rebuilding of the Great Western Railway Company's new station at Bristol Temple Meads, which will occupy close upon four years, and will cost about a million and a quarter pounds. The new station will occupy an area nearly three times that of the present station, and will involve the rebuilding of the suburban stations of Bedminster and Parsons-street. The scheme provides for the quadrupling of the line between South Wales Junction and Portishead Junction, and the provision of additional running lines, a new locomotive depôt, with two 65ft. turntables and new siding accommodation. Instead of the present nine platforms, there are to be eleven platforms at the new station, the longest of which will be 1230ft. By the use of two platforms, lengths of 1370ft., 1300ft., and 1050ft. can be obtained, so that the longest trains will be easily accommodated. The present up main platform is to be nearly doubled in width, and the present footbridge will be superseded by spacious subway for passengers and luggage, which will be connected to all platforms, the entrance and the booking hall by means of sloping approaches. A separate subway for parcels traffic is also to be built, and practically the whole of the platform area will be under cover.

The Automatic Stabilisation of Ships.

No. I.

BEFORE we can discuss satisfactorily the automatic stabilisation of ships at sea, it is necessary that we should study certain general features of the behaviour of vessels in still water and among waves. Only when we have clear ideas concerning at least the outlines of the somewhat complex problem presented by the elucidation of that behaviour can we appreciate properly the principles involved in the design of specific means for achieving the desired stabilisation.

A ship floating in still water and heeled over behaves when released very similarly to a swinging pendulum. Every ship in such circumstances exhibits a definite period of oscillation. This still-water, or "natural," period is very closely given by the formula—

$$T = 2\pi \sqrt{\frac{k^2}{g\,m}}$$

where k is the radius of gyration of the vessel about an axis passing through the centre of gravity of the vessel, and m is the metacentric height. The formula follows mathematical convention by defining the period as the time taken by the vessel to swing from one extreme out position to the other and back again. It is, or was, the practice of the British Admiralty to define the period of a ship as the time taken by her to swing from one extreme out position to the other. The mathematical period is therefore twice the Admiralty period. We propose throughout to follow the mathematical convention.

Like the ordinary formula for the period of oscillation of a pendulum, the expression quoted is only approximately true. It may be taken as being substantially correct for rolls, out-to-out, amounting to anything up to 10 deg. or 15 deg. As in the case of the pendulum, the oscillation of a ship is not strictly isochronous. As the amplitude increases, the period lengthens. At amplitudes which, though high, are still within the range which the vessel may experience at sea, the period of oscillation may be greater than the value indicated by the formula by an amount which can, as will be shown presently, have an important effect on the safety of the ship.

It is to be noted that since the formula involves the metacentric height and the radius of gyration, the period of oscillation of a ship depends to some extent on the amount and distribution of her cargo and is therefore not completely determined by her form and weight as given to her by her builders.

The actual still-water periods of ships vary considerably. In a vessel of the destroyer type the radius of gyration is small, and the metacentric height is relatively great. The rolling period is therefore short, and may be as low as 4 seconds. In a heavily armoured warship the metacentric height may be considerable, but the radius of gyration is exceptionally high, because of the presence of the side and deck armour. The rolling period is therefore high and may reach 16 seconds. In an Atlantic liner the metacentric height is small relatively to the radius of gyration, and as a consequence the rolling period may be as high as 24 seconds, or even more.

Having briefly considered the natural periods of ships, we have now to note a few facts concerning the natural periods of sea waves. The period of a train of waves is the time elapsing between the appearance of two crests—or two hollows—at some fixed point such as a pole projecting vertically from the bed of the sea. This period is not quite the same as the interval elapsing between the breaking on the shore of two successive waves of the train, for, as the waves travel in from deep to shallow water, their length, height, and period are altered. According to the modern trochoidal wave theory, each particle of water moves in a comparatively small circular orbit lying in a vertical plane. The velocity of the wave—that is, the speed of advance of the wave crest—may be high, but it is not accompanied by an actual transference of water at that speed. A given particle of water is not carried forward from wave crest to wave crest. Moving in its circular orbit it reappears time after time in the wave crests occurring at the one position.

At sea it is perhaps exceptional to encounter a train of waves obeying a simple law. In general, two or more trochoidal series, not always moving in the same direction, are imposed on one another. The successive waves of such a confused sea differ in size and form. It is the presence of two or more series of waves which causes the phenomenon that has given rise to the popular belief that every seventh wave is a big one.

The period of a single series of deep-sea waves varies very considerably. It is believed that 24 seconds is the extreme maximum ever reached under exceptional conditions. Large waves commonly encountered in a storm have a period of from 6 to 9 seconds.

We have now to consider what happens when a vessel having a natural still-water period of from 4 to 24 seconds is placed among deep-sea waves having a period of anything up to 9 seconds or so. The modern theory of rolling was established by the late William Froude and differs essentially from earlier views on the subject. It was at one time held that rolling was caused by the impact of the waves against the side of the vessel. This opinion is no longer sustained. It had to be abandoned because it was found that violent rolling was sometimes experienced on a long smooth swell which delivered little or no shock against the sides of the vessel. The modern view is that the rolling motion is the product of the fluid pressure acting on the hull of the ship. A vessel floating in still water on an even keel is maintained upright with her masts parallel with the normal to the water surface because the fluid pressure acting over the starboard half of the hull is exactly counterpoised by the fluid pressure acting over the port half. On the slope of a wave equality of the fluid pressure will occur if the masts are parallel with the normal to the wave surface at the point on the slope at which the vessel is momentarily stationed. In other words, the natural "upright" position for a vessel on the slope of a wave is that in which her masts are normal to the wave surface. To that position the fluid pressure acting on her hull will tend to move her if for any reason she is displaced from it. The normal to the wave surface is vertical at the crests and at the hollows and reaches the maximum inclination to the vertical about halfway down the slope. Strictly speaking, we ought not to speak of the wave surface, but of the effective wave surface. The hull of the vessel extends appreciably below the actual wave surface and encounters a distribution of fluid pressure which is modified by the fact that the trochoidal wave form changes and becomes flatter and eventually disappears as we pass downwards. It is estimated, for example, that at a depth of one-ninth of the wave length below the surface the height from crest to hollow of the wave is only one-half what it is at the actual surface. For a vessel of given draught the effective wave surface is intermediate in form between the actual surface and the sub-surface reached by her keel. It is the normals to this effective surface that mark the natural "upright" positions of equilibrium for the ship at different points on the wave slope.

Let us suppose that a vessel without sensible moment of inertia is exposed broadside on to a train of waves. Because of the absence of inertia the vessel would respond instantaneously to the changing inclination of the normal to the wave surface and would preserve its masts constantly in alignment with the normal—see A, Fig. 1. The masts would be vertical at the hollows and the crests and would heel away from the vertical to a maximum extent at some point about halfway along the slopes. In other words, the period of rolling would be equal to the period of the waves and the amplitude of rolling would be constant so long as the wave form did not change.

The introduction of inertia quite alters the character of the ship's behaviour. It has the effect of rendering the vessel sluggish in following the changing inclination of the normal to the wave surface. Let us suppose that the ship has an indefinitely great moment of inertia. As the vessel passes up the wave slope from a hollow to a crest—see B, Fig. 1—the fluid pressure will endeavour to bring her masts into coincidence with the wave surface normal. That tendency will be resisted by the great inertia and the vessel will ride up the slope with her masts substantially vertical. Any slight movement of the masts towards the normal which may be acquired before the crest is reached will be immediately counteracted on the succeeding downward slope. On the rising slope the fluid pressure tends to heel the vessel in one direction and on the falling slope to heel it in the opposite direction. The one heeling tendency counteracts the other and the vessel rides over the waves with her masts vertical.

Both these cases are hypothetical, for in practice the inertia of a vessel can neither be zero nor indefinitely great. Consider, therefore, the case of a ship possessing a moderate amount of inertia. For the sake of definition we will take it that in the diagram C, Fig. 1, we are looking from the stern of the ship towards the bow and that the masts are vertical when the ship is at the foot of the first trough D. As the vessel passes up the first slope D E the fluid pressure acts on her hull to heel her over to port. The heeling force starts at zero at D, rises to a maximum about halfway up the slope and falls to zero again at the crest E. On the downward slope E F the fluid pressure acts in the opposite direction; that is to say, if the vessel were vertical at E the fluid pressure acting on her between E and F would tend to heel her over to starboard. The heeling force would again start at zero at E, rise to a maximum some distance down the slope, and fall to zero at F. On the next slope the heeling force as indicated by the curve would repeat its form over the first slope D E and so on as long as the wave form persisted.

For the sake of simplicity we may replace the continuously acting heeling forces by a series of instantaneous impulses J K L M, &c., occurring at the mid-points of the slopes and acting alternately in opposite directions. The interval elapsing between the application of two successive impulses, it will be seen, is equal to half the period of the waves.

Consider now a vessel floating in still water and subjected to such a series of impulses. The first one J will heel her over to port and will start her oscillating in her own natural period. The subsequent behaviour of the vessel will depend upon the ratio of her natural period to the period of the impulses.

It may be that her period is exactly equal to the period of the waves; that is to say, exactly equal to twice the period of the impulses. If, then, she is vertical when the first, portwards, impulse J is received she will just have recovered her vertical position and be swinging over to starboard when she receives the second, starboardwards, impulse K. She will again be vertical and be moving to port when the next portwards impulse L is received, and so on. It will be seen, therefore, that the impulses synchronise with the movements of the vessel. When she is beginning a roll to starboard she receives an impulse which augments her movement in that direction, and when she is beginning a roll to port she receives a portwards moving impulse. It is evident, therefore, that the rolling will build up, the angle reached in one direction exceeding the angle from which she has just recovered in the opposite direction.

In a comparatively short time the vessel would capsize were it not for two facts. In the first place, as already noted, her oscillatory motion is not perfectly isochronous. Her period may be exactly equal to twice the interval elapsing between the first two impulses J K, but as the roll builds up her period will lengthen. As a consequence she is not quite vertical when the impulse L is received and still less not quite vertical when she receives the impulse M. The out-of-phase effect builds up and ultimately a time will come when the impulses, instead of acting with the movement of the ship, will act against it, and therefore tend to check the roll. In general the anachronism of the ship's movement is not sufficiently marked to save her by itself from capsizing.

Of much more importance to the safety of the vessel is the fact that the rolling motion, contrary to what we have hitherto tacitly assumed, is not unrestricted. It is subject to a damping effect from the water just as the swinging of a pendulum is subject to damping forces produced by the resistance of the air and friction at the suspension. The impulses applied by the escape wheel to the pendulum synchronise with its swings, but they do not cause the amplitude to increase indefinitely. Very shortly

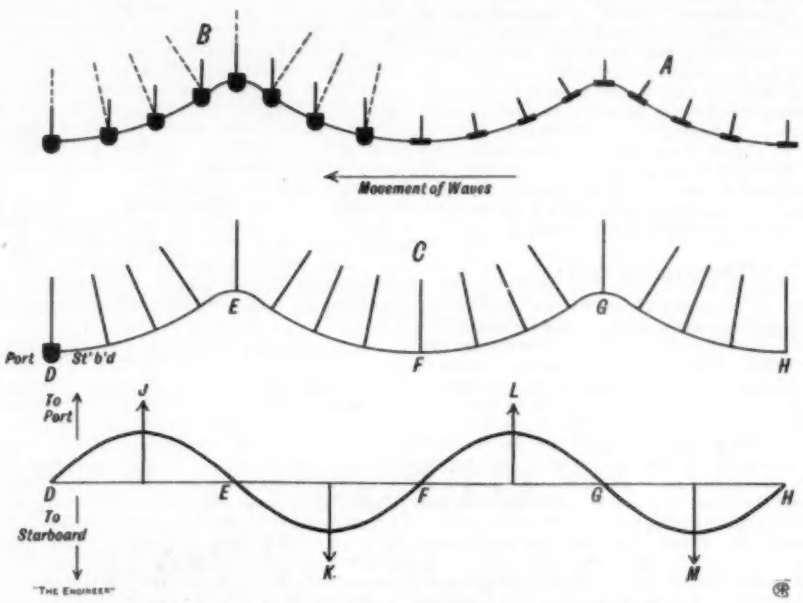


FIG. 1—DIAGRAMS ILLUSTRATING THE ROLLING OF SHIPS

after the start of the swinging movement the amplitude reaches a limiting value, namely, that value at which the energy given to the pendulum by the impulses over any period is equal to the energy lost by it during the same period against the resistance of the air and the frictional drag. Similarly, in the case of a ship in the conditions assumed, a limiting value for the amplitude is set by the attainment of equality between the work done by the heeling forces and the work expended against the fluid resistance.

It may happen that this limiting value lies too far beyond the safe range of rolling to save the ship from capsizing. We can therefore conclude that a ship is exposed to danger if she is allowed to lie broadside on to waves the period of which is equal to her own natural period. It should be realised that the danger arises as much from the fact that the periods are equal as from the magnitude of the heeling forces. Even although the individual wave impulses are small, they may in time build up a dangerous angle of rolling. The fitting of bilge keels reduces the danger by securing an increase in the fluid resistance experienced by the ship. If the waves are not a simple train, but are of the usual confused variety, the danger is, generally speaking, lessened.

Similar consideration may be given to the case of a vessel the natural period of which is equal to twice that of the waves to which she is exposed. The first impulse J rolls the ship to port and starts her oscillating in her natural period. At the full out port position she receives the impulse K, which helps her to recover the vertical position. As she is passing through the vertical and starting a roll to starboard she receives the second portwards impulse L, which acts against the acquired movement. At the full out starboard position she receives the second starboardwards impulse M, which opposes her return to the vertical. The fifth impulse is received when the ship is vertical and starting a roll to port and, like the first, rolls her to port. The succeeding impulses are a repetition of the second, third, fourth, and fifth. Of any group of four one rolls the ship away from the vertical to port, another helps her to recover the vertical position, a third checks the succeeding roll to starboard, and the fourth opposes the recovery of the vertical position. Two of the impulses, therefore, cause the vessel to depart from the vertical and two of them help her to recover it. In these circumstances the vessel will not remain steady. She will roll in her own natural period. The rolling is, however, checked as much as it is encouraged, and accordingly the amplitude of the rolling movement attains a value beyond which it shows no tendency to increase.

If we take the periods of ships as extending from 4 to 24 seconds and the periods of waves as extending normally up to 9 seconds, then it is clear that the long period vessel, of the liner or battleship type, will never, outside phenomenal circumstances, encounter the dangerous conditions covered in the first case we have considered. The short-period vessel of the destroyer type may, however, be fully exposed to them, although equally probably she may encounter the particularly safe conditions covered in our second case.

In general, however, the ratio of the ship period to the wave period is neither exactly two nor exactly one, but some fraction proper or improper. It is hardly necessary for our present purpose to discuss this general case in detail. It is sufficient to note the result. If the ratio is fractional, the amplitude of the rolling movement will fluctuate. For a time, it will increase with each roll. Having reached a maximum, it will begin to decrease and thereafter will rise and fall over regular periods. If, for instance, a vessel having a period of 24 seconds encounters waves having a period of 9 seconds, the amplitude will increase over three rolls and diminish over the next three, the cycle occupying a period of 72 seconds. Much longer phase periods are, however, possible. For example, if the ship's period is 23·8 seconds, and the wave period is 9 seconds as before, the phase time will be 1071 seconds, and during it the vessel will make 45 rolls, showing an increasing amplitude and 45 rolls with a diminishing amplitude. The phase time is the period elapsing between two successive appearances of the ship and the waves in any given configuration relatively to one another.

As an important corollary to what has just been said, it may be remarked that the rolling of a ship can obviously only be measured properly if the record is extended continuously over a considerable number of rolls. An isolated measurement is clearly next to valueless.

(To be continued.)

IN commenting on the explosion of a water-tube boiler in a cement works the Engineer-Surveyor-in-Chief, Board of Trade, says that it occurred in a boiler of which regular inspection had been made and to which every attention had been given to ensure efficient maintenance. Arrangements for preserving the purity of the feed water necessary for this type of boiler were provided. These arrangements had been in existence for a considerable time, but it is thought that some of the scale may have escaped notice, so that in spite of the precautions taken a local accumulation had occurred, resulting in overheating and consequent failure of one of the tubes. This tube was one of the tubes originally fitted in the boiler 17 years ago, and it is probable that its age was a contributory cause of its failure.

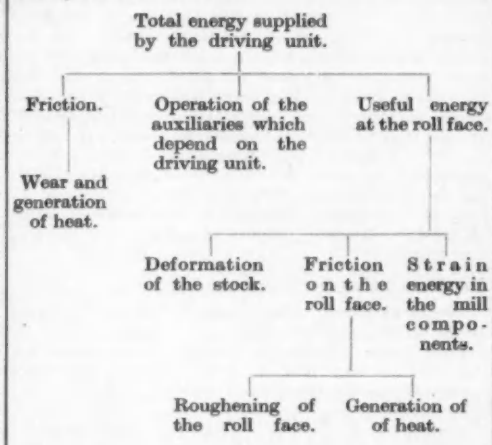
The Rolling of Metals.

By J. SELWYN CASWELL, M.Sc., A.M.I. Mech. E.

No. VI. *(conclusion).**

THE ACTUAL ENERGY REQUIREMENTS.

THE actual amount of energy required by a rolling mill to produce a given deformation is much greater than that given by the equations discussed in the previous article, and its distribution in the mill is mainly that shown below.


Total energy supplied by the driving unit.
Friction.
Operation of the auxiliaries which depend on the driving unit.
Useful energy at the roll face.
Wear and generation of heat.
Deformation of the stock.
Friction on the roll face.
Strain energy in the mill components.
Roughening of the roll face.
Generation of heat.

The greater part of the energy is taken up by friction and the deformation of the stock, the former consuming anything from 25 per cent. to 90 per cent. of the total energy supplied.

The probable distribution of the energy in the case of mills for rolling sheets, tin-plates, and metal strip has been discussed by the writer elsewhere,[7] and in the case of one mill it is shown that during a first pass 82 per cent. of the energy is usefully employed, while in a last pass, after considerable lengthening of the stock has taken place, only 35 per cent. of the energy is usefully used, the balance, viz., 65 per cent., being used principally to overcome friction. The energy loss due to friction has been much diminished in recent years by the use of roller bearings and Michel bearings, accurately cut gearing, improved spindle and wobbler drives, and well-designed lubricating systems.

The importance of correct alignment and the effect of bad alignment have been discussed in a previous paper,[7] and the subsequent discussion on that paper indicates the considerable influence which alignment conditions have on the energy required to operate the mills.

The energy at the roll face will include that required to deform the stock and that required to overcome friction on the roll face, and an expression for this energy has been developed in the paper just referred to. The expression is given below and it applies to the rolling of flat stock.

$$\text{Roll face energy} = \frac{0{\cdot}68\,R\,L\,(T-t)}{D\,\theta}\ \text{H.P. secs.}$$

It is shown, too, that

$$\theta = \sqrt{\frac{2\,(T-t)}{D}}$$

$$\therefore \text{Roll face energy} = 0{\cdot}68\,R\,L\,\sqrt{\frac{T-t}{2\,D}}\ \text{H.P. secs.}$$

where R = total resistance to deformation over the contact area of the "bite" in tons,
L = the length of the stock after the pass in inches,
T = the thickness of the stock before the pass in inches,
t = the thickness of the stock after the pass in inches,
D = the diameter of the rolls in inches.

The value of $R = f_b\,b\,S$, where
f_b = the apparent value of the plastic stress, tons per square inch,
b = the width of the stock in inches,
S = the length of the contact arc on the roll face in inches

$$= \frac{D}{2}\,\theta = \frac{D}{2}\sqrt{\frac{2\,(T-t)}{D}}$$

$$= \sqrt{\frac{D}{2}\,(T-t)}\ \text{inches}$$

The expression for the roll face energy may now be written as follows :—

$$\text{Roll face energy} = 0{\cdot}68\,f_b\,b\,L\,\frac{T-t}{2}\ \text{H.P. secs} \quad (18)$$

The ideal amount of energy, just discussed, is

$$= 0{\cdot}68\,f_o\,b\,L\,t\,\frac{T-t}{T+t}\ \text{H.P. secs.} \quad . \quad . \quad (19)$$

* No. V. appeared March 28th.

7 "The Forces Set Up in Sheet and Tin-plate Mills," J. S. Caswell, "Proc.," South Wales Inst. of Engineers, Vol. XLII., No. 2, 1926.

The difference between these two expressions is

$$0{\cdot}68\,b\,L\,(T-t)\left[\frac{f_b}{2} - \frac{f_o\,t}{T+t}\right]$$

$$= \frac{0{\cdot}68\,b\,L\,(T-t)\,t}{T+t}\left[f_b\left(\frac{T+t}{2\,t}\right) - f_o\right]\text{H.P. secs.} \quad (20)$$

and it represents the additional energy required to overcome the friction between the stock and the roll face.

In all of the foregoing expressions the values of the true plastic stress f_o and the apparent plastic stress f_b are the most difficult to obtain, and with our present knowledge these values and the manner in which they vary can be determined only by experimental methods. That for the determination of the value of the true plastic stress has been discussed already, and that for the apparent value f_b could be found by either of the following methods :—

(*a*) By measuring the direct load R set up on each roll by such means as those which have been employed by Puppe on the Continent and by Skinkle in America.

Then $$f_b = \frac{R}{b\,S}$$

(*b*) Measurement by dynamometer of the roll face energy, when the load on the driving unit is made equal to that produced when stock is being rolled, the journal or neck friction load remaining unaltered, and then using the roll face energy equation, *i.e.*,

$$f_b = \frac{2\,E_f}{0{\cdot}68\,b\,L\,(T-t)}$$

where E_f = the energy as measured by the dynamometer.

When the draught is light $(T+t)/2\,t$ is nearly equal to unity and the value of f_o and f_b are nearly equal.

It is hardly necessary to point out that such measurements would have to be made on an experimental rolling mill in which provision is made for studying rolling mill problems. The experimental rolling mill in the Carnegie Institute of Technology, Pittsburg, and the recently installed mill at Sheffield University, are interesting examples of such mills.

THE ENERGY REQUIREMENTS FOR THE ROLLING OF SECTIONS.

The expression for the ideal amount of energy may be written in the form

$$f_o\,V\log_e\frac{L}{L'} = 2\,f_o\,V\left(\frac{L-L'}{L+L'}\right) \quad . \quad (21)$$

where V = the volume of the material undergoing deformation,
L′ = the original length of the stock,
and the other terms have the values already assigned to them.

If the draught is small L is nearly equal to L′, and then since $V = A\,L = A'\,L'$, *i.e.*, the products of the area of the cross section and the length before and after the pass, the expression reduces to the simple form given below :—

$$f_o\,A'\,(L-L')\ \text{inch-tons}$$

$$= \frac{2240}{12\times 550}\,f_o\,A'\,(L-L')\ \text{H.P. secs.}$$

$$= 0{\cdot}34\,f_o\,A'\,(L-L')\ \text{H.P. secs.} \quad . \quad . \quad (22)$$

It has been assumed that the value of f_o is not affected by slip, and the discussion regarding its value applies in this case also.

If the roll face energy is measured along with the lengths of the stock, before and after a pass, the apparent plastic stress values could be calculated, and these could be expressed in the form

$$f_b = K\,f,$$

where K is some constant for the conditions under which the metal is rolled.

Considerable differences in the value of f_b may occur for equivalent changes in the area of the cross-section, and therefore the effect of the section profile should be embraced by the results of such experiments. The easiest way to include this factor would be to relate the observed values to the following ratio :—

$$\frac{\text{Area of the cross section}}{\text{Mean vertical thickness of the cross section}}$$

The measured roll face energy would include the energy which is taken up by friction when the stock is rolled, and an estimate of this may be obtained by deducting the ideal amount of energy from that determined by measurement.

Friction between the stock and the rolls has a considerable influence on the energy required for rolling sections, and there is no doubt that an experimental mill equipped for investigating this matter would provide valuable information for the purposes of pass design.

FRICTION IN THE ROLLING MILL.

Friction is here regarded as that occurring in the mill bearings and gearing.

The estimation of the energy required to overcome friction is rendered difficult by the fact that the total friction load alters with every change in the rolling load in the mill.

The greater part of the energy used in overcoming friction is taken up by the mill bearings, and it is

sufficient to discuss the energy to overcome friction from this point of view. When the energy accounted for by the mill bearings can be calculated it is not difficult to estimate how much energy is accounted for by the operation of the other parts of the mill.

The energy which is required to overcome friction in the bearings of a rolling mill with bearings of the ordinary type is approximately represented by the following expression, which has been discussed in a previous paper.[7]

$$\text{Energy to bearings} = 0{\cdot}68\ \text{R L}\ \mu\ \frac{d}{\text{D}}\ \text{H.P. secs.}$$

where the new terms μ and d have the following values:

μ = the coefficient of friction in the bearings,
d = the diameter of the roll necks or journals, in ins.

For plain rolls which are used in the rolling of sheets and plates the expression may be written as below:—

$$0{\cdot}68\ f_b\ b\ \text{S L}\ \mu\ \frac{d}{\text{D}}\ \text{H.P. secs.} \quad . \quad . \quad (23)$$

in which the terms have the meanings already assigned, and the expressions suggest the following conclusions regarding the energy used in overcoming friction.

(1) For the same ratio of neck diameter to roll diameter and the same draught the energy consumed increases with increasing roll diameter.

(2) With the same roll diameter and draught the energy used decreases with decreasing diameter of the neck.

The Coefficient of Friction.

There is considerable doubt regarding the value of the coefficient of friction, and this is largely due to the difficulty of measuring it under the conditions which are associated with rolling practice.

The following values, although applying to different mills, indicate the wide variation of the values, and they are those made use of by the authorities mentioned:—

0·075, Morin and Puppe.
0·2 to 0·25, Trinks.
0·05, G. M. Brown.
0·035 to 0·05, C. E. Davies.

A close estimate can be made if the energy input to the mill is measured and equated to an expression for the total energy, and the closest approximations are obtained in mills rolling flat stock.

The writer has calculated the probable value of the coefficient of friction in the bearings of a tin-plate mill, and it has been assumed that the plastic stress values are the same as those obtained by Riedel on iron specimens.

The energy input figures were supplied to the writer by Messrs The Upper Forest and Worcester Steel and Tinplate Company in connection with a previous paper.[7] The temperature readings were obtained with an optical pyrometer, and therefore the stress values depend on the accuracy of these readings.

The total energy equation is that formed by the combination of separate equations just discussed, viz.,

$$\text{Total energy} = \frac{0{\cdot}68\ \text{R L}}{\text{D}}\left(\mu\ d + \sqrt{\frac{\text{D}\ (\text{T}-t)}{2}}\right) \text{H.P. secs.} \quad . \quad . \quad . \quad . \quad (24)$$

The necessary data and the calculated values of the coefficient of friction are recorded in the following table.

It is not intended that the foregoing should indicate the values of the coefficient alone, but rather to indicate that the method, when employed for the special purpose of determining the coefficient of friction, would give fairly accurate values.

The values obtained above indicate that the value of the coefficient of friction in the case of tin-plate mill necks or bearings, and probably in the case of sheet mills, too, varies from 0·1 to 0·15.

The bearing pressures in these mills range from 2 to 3 tons per square inch, and data regarding friction characteristics under the conditions applying to sheet and tin-plate mills and suchlike are scanty. It is not improbable that a large amount of energy is unnecessarily lost as a result of the bad design of these bearings and the use of unsuitable grease. In this connection the writer recalls an incident regarding the substitution of one grease for another in a cold rolls for rolling sheets. The lower viscosity of the new grease suggested the substitution, and the electric driving unit rendered it possible to observe the effect of the change. The substitution was entirely successful, and there was an appreciable reduction in the energy demand. The difficulty of obtaining an idea of the energy demand in steam-driven mills allows a considerable amount of energy to be wasted, unnoticed.

The Total Energy Required to Operate a Mill.

The total energy is here regarded as that supplied at the wobblers of the rolls.

Flat Rolls.—When the energy expressions for deformation and friction are combined the total energy expression becomes

$$0{\cdot}68\ f_b\ b\ \text{L}\ \sqrt{\frac{\text{T}-t}{2}}\left(\frac{\mu\ d}{\sqrt{\text{D}}} + \sqrt{\frac{\text{T}-t}{2}}\right) \text{H.P. secs.} \quad . \quad . \quad (25)$$

for rolling flat stock, and this is a modification of the form (23) given above, for the purpose of isolating the plastic stress f_b. The values of f_b could be deduced from laboratory test data.

Section Rolls.—The expression for the total energy in the case of section rolling would have the following form:—

$$0{\cdot}68\left[\mu\ \text{R}\ \text{L}\ \frac{d}{\text{D}} + f'_b\ \frac{\text{A}'}{2}\ (\text{L}-\text{L}')\right] \text{H.P. secs.} \quad . \quad (26)$$

but here the values of R and f'_b are not so easily determined. The term R respresents the resultant load on the roll bearings and f'_b represents the apparent plastic stress value as calculated from the energy supplied at the roll face.

The value of R is related to the horizontal projected area of the stock, and therefore for equivalent changes in the cross section of the stock as rolling proceeds there would be different values of R and, consequently, different values in the energy taken up by bearing friction.

This suggests that the method adopted by Puppe, of expressing the energy requirements in terms of the volume of material displaced, is not sufficiently correct. The correctness of the method has been disputed also on other grounds by Tafel.

A more suitable expression for the work done in section rolling may be obtained as follows:—

The expression for the ideal amount of energy is $f_o\ \text{A}'\ (\text{L}-\text{L}')$ inch-tons, and the main factors which give rise to a greater demand for energy in the rolling mill are as follows:—

(1) The occurrence of considerable friction between the stock and the surface of the roll.

(2) The friction in the mill bearings, and the load on the bearings depend on the physical condition of the stock, the diameter of the roll, the draught, and the horizontal projected area of the stock. Each of these is considered below.

(*a*) The only satisfactory method of determining the effect of friction between the stock and the roll face is by direct measurement of the roll face energy for the purpose of obtaining the value of the apparent plastic stress, and relating this to the ratio of the area of the cross section and the mean depth of the section. The roll face energy would then be expressed, as explained already, by the following:—

$$\text{Actual roll face energy} = \text{K}\ f_o\ \text{A}'\ (\text{L}-\text{L}').$$

(*b*) The energy required to overcome friction depends on the factors referred to above, and the ratio $\dfrac{\text{Friction energy}}{\text{Roll face energy}}$ will vary from pass to pass.

This ratio may be expressed in simple terms and reference will be made to flat rolling for this purpose. It was shown that the total energy for flat rolling is

$$0{\cdot}68\ f_b\ b\ \text{L}\ \sqrt{\frac{\text{T}-t}{2}}\left(\frac{\mu\ d}{\sqrt{\text{D}}} + \sqrt{\frac{\text{T}-t}{2}}\right)$$

$$\therefore \quad \frac{\mu\ d}{\sqrt{\frac{\text{D}\ (\text{T}-t)}{2}}} = \text{ratio}\ \frac{\text{Friction energy}}{\text{Roll face energy}}$$

$$\sqrt{\frac{\text{D}\ (\text{T}-t)}{2}} = \frac{\text{D}}{2}\ \theta = \text{S}$$

where θ = angle of contact, S = the length of the contact arc.

$$\therefore \quad \frac{\text{Friction energy}}{\text{Roll face energy}} = \frac{\mu\ d}{\text{S}} = \frac{\text{C}}{\text{S}}, \text{ where } \text{C} = \mu\ d.$$

If the coefficient of friction remains unaltered, as it probably would, C is a constant.

The term S is a variable, and in the case of section rolling it represents the mean length along the roll face of the arc of contact.

Let E = the total energy supplied under actual conditions,
and U = the roll face energy as given by the expression $\text{K}\ f_o\ \text{A}'\ (\text{L}-\text{L}')$. Then

$$\frac{\text{C}}{\text{S}} = \frac{\text{E}-\text{U}}{\text{U}}$$

and

$$\text{U C} = \text{S}\ (\text{E}-\text{U})$$

and

$$\text{E} = \text{U}\left(\frac{\text{C}}{\text{S}} + 1\right)$$

Substituting the values for U and C, the total energy equation becomes

$$0{\cdot}34\ \text{K}\ f_o\ \text{A}'\ (\text{L}-\text{L}')\left(\frac{\mu\ d}{\text{S}} + 1\right) \text{H.P. secs.} \quad . \quad (27)$$

This expression could be used, of course, for estimating the energy required for flat rolling, and in this case the value of K will be near to unity.

In order to test the approximate truth of the foregoing expression the writer has used it for calculating the energy requirements in a tin-plate mill and compared the results with the measured values of the total energy supplied.

The particulars of the mill and the stock and also the passes have been given already in Table I. on this page, and the comparison between the actual energy supplied and the calculated values from the foregoing energy expression are given below.

Table II.—*Comparison of the Actual and the Calculated Energy Required.*

See Table I. for particulars of mill, passes, &c.

Operation.	Pass.	Actual energy supplied.	Calculated energy supplied.
Bars	1	495	462
Bars	4	674	656
Singles	5	1245	1200*
Singles	6	568	606
Doubles	7	1567	1320*
Doubles	8	716	652
Fours	9	1275	1289*
Fours	10	783	735
Eights	11	1203	1093*
Eights	12	No reliable temperature figure	

* μ = 0·16 (Heavy first run passes, finishing mill).

The similarity is remarkably close when it is remembered that the energy expression has been deduced from the preliminary hypothetical considerations and not corrected for possible differences in the values of the plastic stress.

The temperatures of the stock were obtained by optical pyrometer and the stress values have been taken direct from Riedel's curves. The values of the constant K and the co-efficient of friction μ, in the energy equation (27), were assumed to be 1·0 and 0·12 respectively. The variation of the calculated values from the measured values corresponds to a mean value of K = 1·07.

The foregoing comparison is of particular interest because it indicates that the total energy expression is a reasonable one. It is simple in form and it may be used for both flat rolling and section rolling.

The conclusions regarding the energy requirements in the rolling mill are recorded below.

Conclusions Regarding the Energy Requirements in the Rolling Mill.

(1) The ideal amount of energy required to deform a plastic solid is

$$0{\cdot}68\ f_o\ b\ \text{L}\ t\left(\frac{\text{T}-t}{\text{T}+t}\right) \text{H.P. secs. for flat rolling,}$$

and $0{\cdot}34\ f_o\ \text{A}'\ (\text{L}-\text{L}')$ H.P. secs. for section rolling.

(2) When work-hardening of the metal occurs the variation of the plastic stress f_o will increase as deformation proceeds.

(3) An additional amount of energy is required to overcome friction: (*a*) between the surface of the stock and the roll face; and (*b*) between the mill components.

(4) The energy required to overcome the friction between the roll face and the stock plus the energy usefully employed in producing deformation, comprises the roll face energy, and its amount is approximately represented by the

Table I.—*Calculated Values of the Coefficient of Friction in a Tin-plate Mill.*

Obtained by equating the total energy equation to the energy input.

Particulars of the Mill and Stock.—Rolls, 21in. diameter by 26in. by 16¼in. necks; stock, initial dimensions; a tin-plate bar, 20·5in. by 8in. by 0·813in. thick.

Operation.	Pass.	Length. Before.	Length. After.	Draught.	Temperature.	Riedel's plastic stress values.	Total energy.	Calculated values of the coefficient of friction.
		Inches.	Inches.	Inches.	Deg. Cent.	Tons/sq. in.	H.P. secs.	μ.
Bar	1	8	11	0·223	835	11·75	495	0·116
No temperature record for passes 2 and 3								
Bar	4	22	30	0·079	835	11·75	674	0·136
Singles	5	30	51	0·089	900	10·1	1245	0·16
Singles	6	51	64	0·025	860	11·0	568	0·11
Doubles	7	32	52	0·079	835	11·75	1567	0·20
Doubles	8	52	65	0·025	820	12·0	716	0·12
Fours	9	32·5	49	0·068	775	13·3	1275	0·16
Fours	10	49	60	0·024	750	14·0	783	0·14
Eights	11	30	45	0·072	820	12·0	1203	0·17
Eights	12	No temperature record for this pass.						

The passes 1 to 4 take place in the roughing mill and the remainder in the finishing mill.

The mean values are, therefore, as follows:—

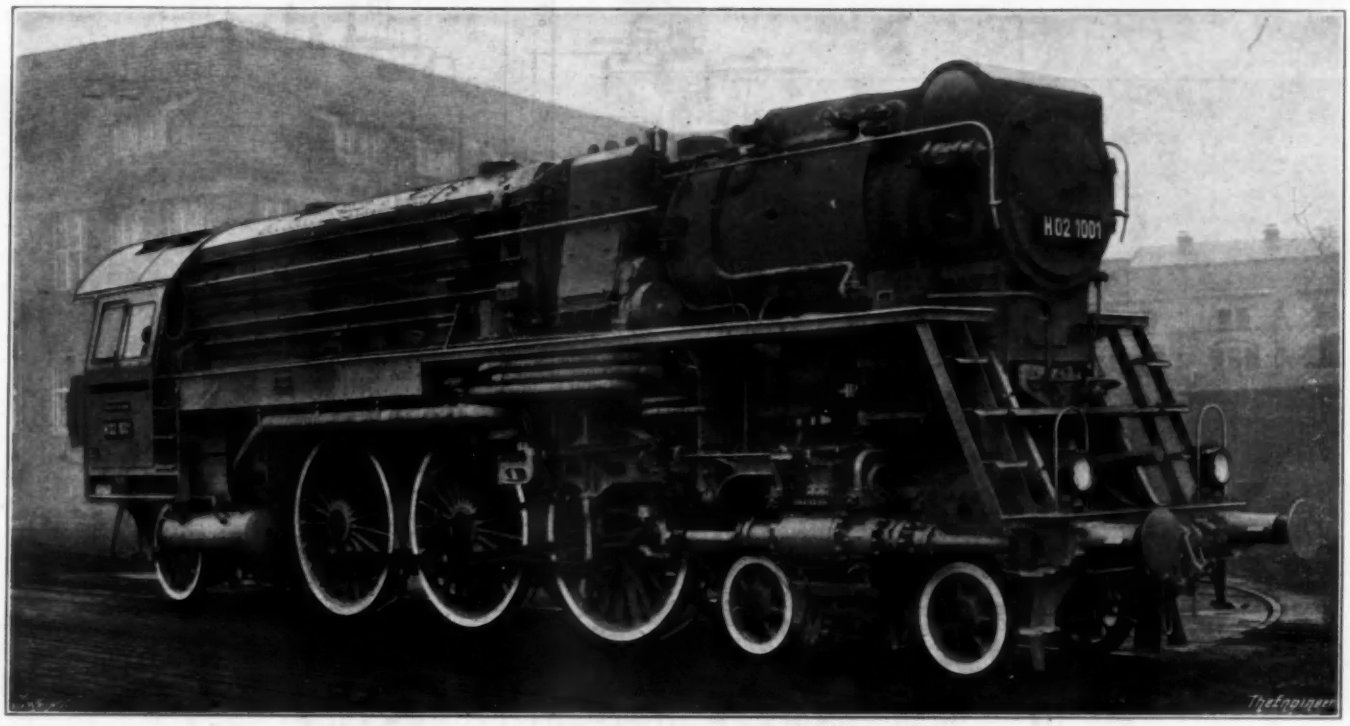
The roughing mill .. .. 0·12
The finishing mill .. .. 0·15

It is of interest to note that there is a high and a low value of the coefficient in each "part," the lower value being given in the second pass in each case, and it suggests that the co-efficient of friction is greater when the heavy first passes are rolled.

It is probable that the coefficient would be lower in the case of the finishing mill, because the neck grease has a lower viscosity on account of the higher temperature of the necks in this mill, about 300 deg. Cent. compared with approximately 150 deg. Cent. in the roughing mill.

GERMAN FEDERAL RAILWAY SUPER-PRESSURE LOCOMOTIVE

BERLINER MASCHINENBAU A.G. (L. SCHWARTZKOPFF), BERLIN, ENGINEERS



expressions given above. When there is considerable slip the roll face energy is greater, and then there is a greater difference between the true plastic stress value and the apparent value, and the amount of the roll face energy can be determined only by experiment.

(5) The greater part of the energy required to overcome friction between the mill components is taken up in overcoming neck friction, its amount varying from 25 per cent. to 90 per cent. of the total energy supplied. The loss of energy in roll neck friction is approximately represented by the following :—

$$\text{Friction energy} = 0{\cdot}68\ \text{R L}\ \mu\ \frac{d}{\text{D}}\ \text{H.P. secs.}$$

(6) The coefficient of friction for heavy mill bearings is considered to range from 0·05 to 0·25, and for lighter mills from 0·035 to 0·05. Calculations based on the measured values of the energy input and experimental plastic stress values indicate that the coefficient of friction in bearings, like those in sheet and tin-plate mills, varies from 0·1 to 0·15.

(7) The expression for the total energy required at the wobblers of the rolls under rolling conditions is

$$0{\cdot}34\ \text{K}\ f_o\ \text{A}'\ (\text{L}-\text{L}')\left(\frac{\mu\ d}{\text{S}}+1\right)\ \text{H.P. secs.}$$

and this may be used for calculating the energy requirements in flat rolling and in section rolling. The value of K approaches unity when there is little slip, *e.g.*, in flat rolling, and it increases as the shape of the section becomes more complex.

(8) Comparison of the results calculated from this expression, with measured values of the energy input, suggest that fairly close estimates of the energy requirements can be made by using it.

Super-Pressure Schwartzkopff-Löffler Locomotive.

IN an article which appeared in our issue of November 15th, 1929, we described the new method of steam raising associated with the name of the late Professor Dr. Löffler, of the Technical High School at Charlottenburg, and outlined the progress made with this system since the first experimental Löffler boiler was put to work at the Floridsdorf locomotive works near Vienna in the latter part of 1924. The principal installations to which we referred were the larger power plant at Vienna and a larger installation at the Witkowitz coal mines in Czechoslovakia, but brief mention was also made of a super-pressure locomotive embodying the Löffler principle which was ordered by the German Federal Railway Company some time ago from the Berliner Maschinenbau Acktien Gesellschaft vormals L. Schwartzkopff, of Berlin, which firm is the licensee for the Löffler system. This locomotive has now been built, and has undergone preliminary trials, and in the following article we give an account of its principal features. It operates at a designed working pressure of 120 kilos. per square centimetre, or 1700 lb. per square inch, and its duty is similar to that of a standard express engine of the German Federal Railway Company. The locomotive has been designed and built in close co-operation with the Reichsbahn officials, and its weight has been kept the same as that of the standard express locomotive. We are indebted to the builders for the accompanying photographs and drawings, and for the particulars given in an article by Reichsbahndirektor Fuchs, which appeared in *Die Reichsbahn* of January 8th last, which journal is the official organ of the railway administration.

It will be recalled that the Löffler principle consists in evaporating water to steam in a non-fired water and steam drum, by means of highly superheated steam, which is introduced into the water in a finely divided form. The system is one which is particularly advantageous at high pressures, and it has the outstanding merit for locomotive work that the difficulty of boiler scale is entirely overcome, as the fire is only utilised to supply heat to a high-pressure superheater, the surfaces of which are not affected by boiler-scale.

DETAILS OF THE NEW LOCOMOTIVE.

We give above a side view of the locomotive, which is of the three-cylinder compound type, and on page 372 drawings showing a side view and a plan view are reproduced. The principal dimensions are as follows :—

Cylinders.	
Diameter of high-pressure cylinders	220 mm.
Stroke of high-pressure cylinders	660 mm.
Diameter of low-pressure cylinder	600 mm.
Stroke of low-pressure cylinder	660 mm.
Wheels.	
Diameter of driving wheels	2000 mm.
Diameter of leading wheels	850 mm.
Diameter of trailing wheels	1250 mm.
Boiler Pressures.	
High-pressure boiler	120 kilos. per sq. cm.
Low-pressure boiler	15 kilos. per sq. cm.
Heating Surfaces.	
High-pressure superheater	90 sq. m.
Low-pressure superheater	32 sq. m.
High-pressure feed heater	71 sq. m.
Low-pressure boiler	82 sq. m.
Grate area	2·4 sq. m.
Weights.	
Calculated weight, empty	111·6 metric tons
Calculated weight, running	114·8 metric tons
Adhesive weight	60·0 metric tons

The diagram given in Fig. 1 illustrates the working principle. The fire-box, as in the Schmidt-Henschel two-pressure locomotive,* consists of a system of small tubes connected to horizontal headers at either side. A second nest of tubes is connected to those forming the fire-box, and is arranged at the

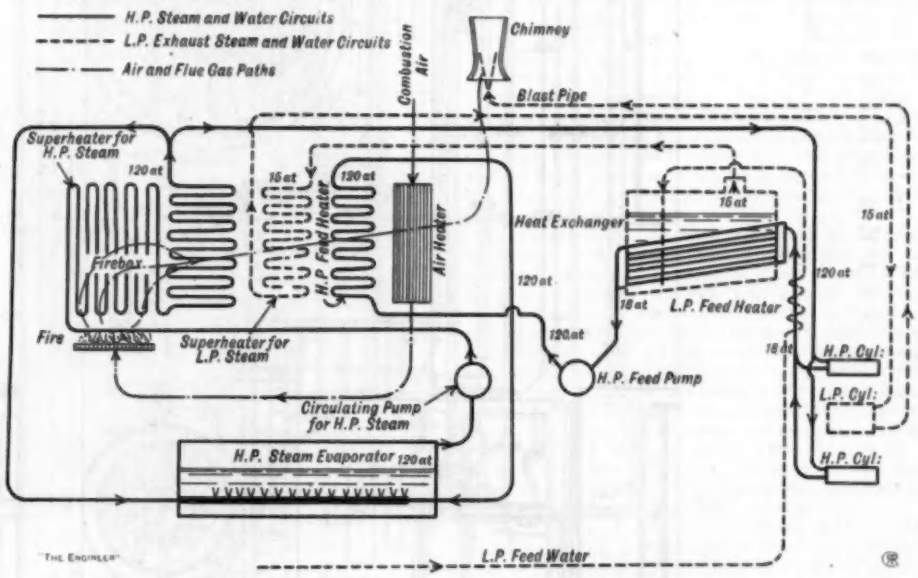
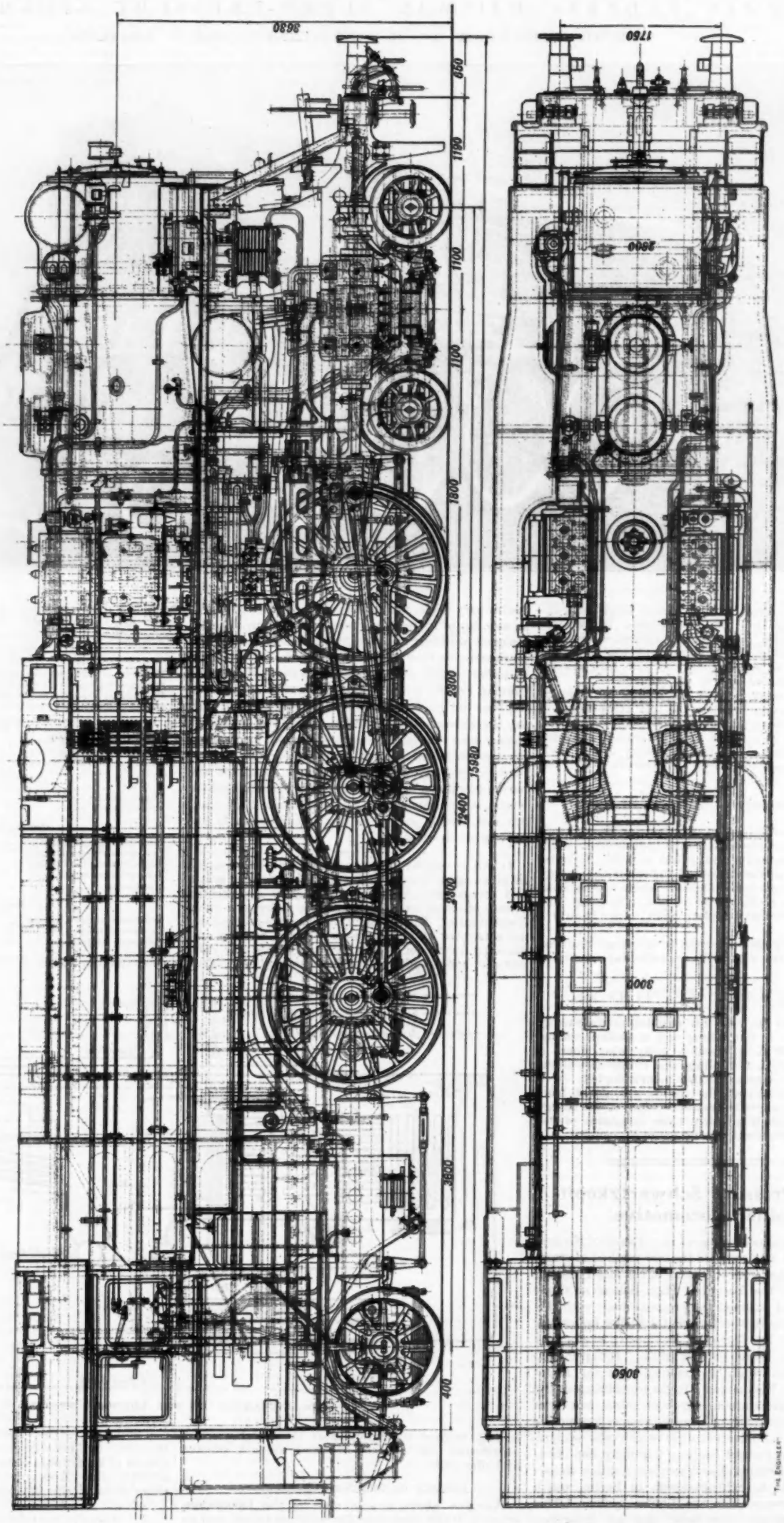


FIG. 1—DIAGRAM OF THE LOEFFLER SYSTEM

* See THE ENGINEER for January 20th, 1928.

SUPER-PRESSURE SCHWARTZKOPFF-LOEFFLER LOCOMOTIVE

BERLINER MASCHINENBAU A.G. (L. SCHWARTZKOPFF), BERLIN, ENGINEERS



front, and through these tubes high-pressure steam at 100 kilos. to 120 kilos. per square centimetre, or 1420 lb. to 1700 lb. per square inch, is pumped by means of a circulating pump. The steam in circulation is thus raised to a total superheated temperature of 450 deg. Cent. Part of this steam flows to the two outside high-pressure cylinders, but the larger amount, steam in the high-pressure circuit, and owing to the small volume of that steam the work of the pump is small, and only one, or at the highest two, per cent. of the energy of the steam generated is utilised for pumping.

The employment of both a high-pressure and a low-pressure circuit, is, the designers point out, not perhaps necessary, but in the first locomotive this arrangement and increased overload capacity is provided by the storage of heat in the water contained in the heat exchanger.

Method of Starting Up.

In order to prepare the locomotive for service, the high-pressure steam evaporator and the steam

Fig. 2—Water-Tube Fire-Box

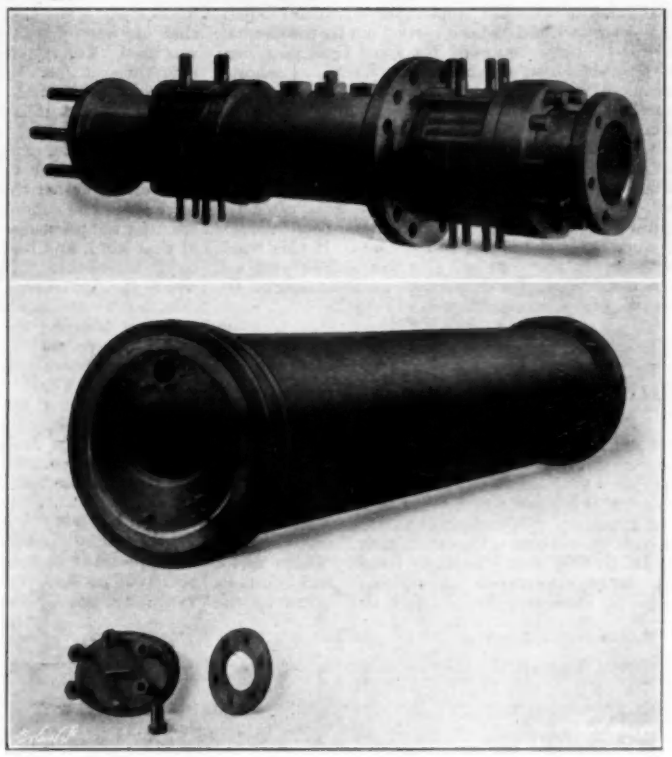


Fig. 3—High-Pressure Cylinder and High-Pressure Evaporator

some 3½ times that flowing to the cylinders, is led to the high-pressure steam evaporator, a drum partly filled with water, which works at the same pressure as the high-pressure superheater. As shown in the lower part of Fig. 1, the high-pressure steam enters through a drowned pipe provided with fine perforations, so that the escaping steam giving up its superheat evaporates a corresponding quantity of water. The circulating pump draws saturated steam from the steam space of the drum and the cycle is a continuous one.

The steam, which is exhausted from the high-pressure cylinders at a pressure of about 18 kilos. per square centimetre, or about 256 lb. per square inch, passes through an oil separator on its way to the heat exchanger, a device which consists of a low-pressure boiler operating at 15 kilos. per square centimetre, or about 213 lb. per square inch. In its design the boiler resembles the ordinary locomotive boiler, with the exception that instead of being directly fired the tubes are traversed by the hot exhaust steam from the high-pressure cylinders. In this way the exhaust steam is condensed, and the condensate is returned to the high-pressure steam evaporator by the high-pressure feed pump through a high-pressure feed heater placed in the path of the flue gases passing from the fire-box.

The steam generated in the heat exchanger or low-pressure boiler is superheated to about 300 deg. Cent. in a low-pressure superheater placed between the high-pressure superheater and feed heater. This steam then passes to the centre low-pressure cylinder, from which it is exhausted to the blast-pipe in the ordinary way. As shown in Fig. 1, an air heater is provided between the high-pressure feed heater and the chimney, and by this means the combustion air is raised to a temperature of about 150 deg. Cent. In Fig. 2 we reproduce a photograph of the water-tube fire-box turned up and arranged in the shops for water testing. The large-diameter tubes at the sides are horizontal at the bottom of the boiler when in position. The upper part of Fig. 3 shows one of the two outside high-pressure cylinders, which are machined from the solid, while in the lower part of the engraving a view of the high-pressure steam evaporator with its manhole cover removed is given. The steam pumps will be seen at the side of the locomotive towards the centre, and between the pumps is the chimney. A more detailed view of one of the two steam circulating pump units is reproduced in Fig. 4.

As will have been noted from diagram Fig. 1, the high-pressure steam circuit is a closed one, in which only steam and distilled water circulate. The raw feed is supplied only to the heat exchanger, so that boiler scale can only be deposited in the low-pressure boiler, but in practice deposition does not take place, as the tubes are steam heated. The steam circulating pump has only to overcome the resistance of the was chosen in order to eliminate any possible deposit of scale in the high-pressure parts of the system. As the velocity of the water through the high-pressure feed heater is, however, high, it is improbable that the deposit of scale in the high-pressure evaporator drum would have been large, even although raw feed had been employed, and in any case scale would not

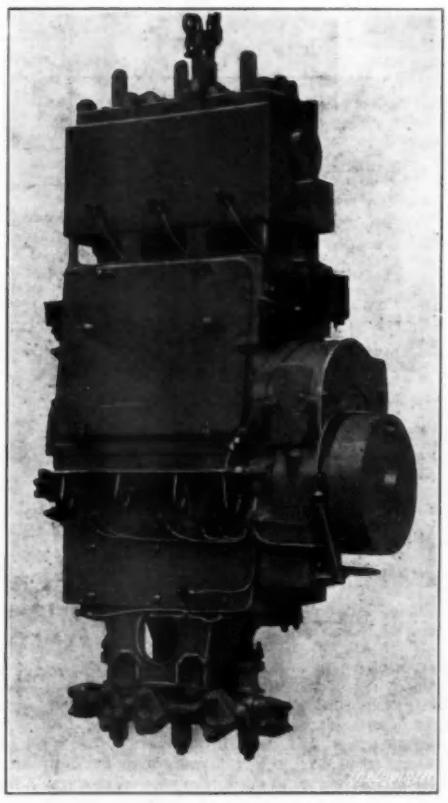


Fig. 4—Steam Circulating Pump

be harmful, as the drum is unfired. Again, if the low-pressure boiler had been dispensed with, the exhaust from the high-pressure cylinders could have been taken direct to the low-pressure cylinder, and a simpler arrangement altogether would have been possible. By including, however, the heat exchanger or low-pressure boiler, additional reliability is ensured

circulating pumps are supplied with steam from an outside source. The pumps are then started and are kept running until a steam pressure sufficient for their operation is obtained. The fire is then lit in the fire-box and the outside supply of steam cut off. The circulating pumps continue to run, and the heat of the furnace increases steadily the working pressure in the high-pressure steam circuit. The fire is so regulated that a maximum pressure of 120 kilos. per square centimetre, or about 1700 lb. per square inch, is not exceeded in the evaporator. Both the evaporator and the heat exchanger are furnished with safety valves.

General Design and Arrangement.

The accompanying drawings and photographs show the general arrangement of the locomotive. The wheel bases and the wheel diameters are generally similar to those of a standard German express locomotive. In front of the water-tube fire-box with its two lower header tubes, there are two nests of high-pressure superheater tubes, the low-pressure superheater, and also the high-pressure feed heater. These three elements are contained in a rectangular chamber, the walls of which form an additional part of the high-pressure feed heater. The top tube wall is detachable, so that the boiler parts which it encloses can be lifted out. The air heater is situated between the high-pressure feed heater and the smoke-box, and air flows to it from both sides, being delivered to the closed ashpan through canals arranged under the footplate.

In the smoke-box there is provided a feed dome, a scum separator, and a steam dome for the low-pressure boiler, and in front of these elements there are two containers, the first and smaller one being the low-pressure heater, and the second or larger one, the oil separator. Below the heat exchanger there is a collecting vessel for the condensed water coming from the tubes of the low-pressure boiler, which water is drawn off by the high-pressure feed pumps. Underneath the feed heater in front of the fire-box there is placed the drum of the steam evaporator. It has a length of 4094 mm., or about 13ft. 5½in., with an internal diameter of 840 mm., or 2ft. 9in. The drum —see Fig. 3—is made from nickel chrome steel, and has a wall thickness of 31 mm., or nearly 1¼in.

As the drawing on page 372 shows, there are two steam circulating pumps, each of which has a designed duty of 75 per cent. of the quantity of steam required at maximum load. Each pump, as shown in Fig. 4, has three cylinders, and coupled with it is the high-pressure feed pump. The pumps are worked by low-pressure steam.

As already stated, the locomotive is of the three-cylinder compound type, with two outside high-pressure cylinders of 220 mm. bore, and one centrally placed low-pressure cylinder of 600 mm. bore, all three cylinders having a common stroke of 660 mm.

There are two driving axles, the low-pressure cylinder driving the front axle and the two high-pressure cylinders the second axle.

After making a number of runs from the Wildau works, in order to check the satisfactory working of the parts, the locomotive has now been handed over to the testing staff at the Grunewald railway shops for the carrying out of further exhaustive trials. The completion of this interesting super-pressure locomotive marks a further step in the advanced experimental work which has been carried out by the German Federal Railway Company for some time past, and which has included experiments with reduced cylinder clearances and higher superheats, also the construction of the high-pressure Schmidt-Henschel locomotive and two condensing turbine locomotives built by Krupp and Maffei respectively. It is hoped that this latest development of the Schwartzkopff-Löffler system will enable a considerable saving in cost of fuel to be effected, so that even after the capital and maintenance charges have been allowed for a substantial margin will remain. If this result be achieved, the builders and the Reichsbahn will have made a further important contribution to the economical operation of steam railways.

Institution of Mechanical Engineers.

A MEETING of the North-Western Branch of the Institution of Mechanical Engineers was held at the Engineers' Club, Manchester, on Thursday, 20th ult., Professor Dempster Smith being in the chair, when a joint paper on "Operating Results with the Recent Extensions at Barton Power Station" was given by Mr. H. L. Guy and Mr. H. C. Lamb. There was a very large attendance of members and visitors. Professor Dempster Smith said they were in the standard steam tables were required, a fact which was very well shown by Table VI.B in the paper. He had great hopes from the Steam Tables Conference which had been inaugurated by the B.E.A.M.A. Great progress was made last July, and he hoped further progress would be made next June, when they were meeting again in Berlin. He thought it a great pity that the condenser results had not been given. He believed that they were very good indeed. He was interested to see that no gain could be obtained in that station by pulverised fuel, unless cheaper coal was used. The conditions on land were very different from those at sea. It was very likely that the problem of pulverised fuel at sea might be much easier than mechanical stoking.

Mr. Adams said, with regard to the condenser performance, the oxygen content at the bottom of the condenser seemed to be rather high at ·08. He wondered whether that was the price they had to pay for having the condensate temperature nearer to the vacuum temperature. He had tried out a condenser of that kind, and had had the same trouble with the oxygen content. In the ordinary type of condenser, where the condensate differed from the vacuum temperature by about 4 deg. or 5 deg., they had no difficulty in keeping the oxygen content entering the economiser to ·05. The oxygen content in the bottom of the condenser was so small that they could not measure it. That, of course, was without any deaerator, which, in his opinion, was entirely unnecessary and was only put in nowadays to make up for faults in badly designed condensing plant. With regard to the operating results, it was a great pity that the boiler-house had been treated as a common unit. It would have been very interesting if the new boiler plant could have been compared with the old boiler plant. What he wanted to know was whether they were justified in heating up feed to 300 deg., and there was no doubt that the "B" engine-room results were very good indeed; but the speaker was disbe determined directly from the routine records. It was, however, the practice of power station engineers to record the efficiency of the boiler-house. If, in addition, the overall efficiency of the station were known, then it was possible to calculate the engine room efficiency. In the N.E.L.A. report of June, 1928, sufficient data were published to calculate the engine-room efficiency in that manner. This he had done, with the results shown in Table I. herewith, which gave also the comparison with Barton. It was satisfactory to note that the results in the two engine-rooms "A" and "B" had been calculated by the authors in two independent ways, and that the difference shown was relatively small. It had been the practice in the past to include the boiler feed pump amongst the boiler-house auxiliaries. That, in his opinion, was not justified in modern practice, neither from the point of view of the steam cycle, nor even from the point of view of location. The duty which was performed by the boiler feed pump was unquestionably part of the cycle of operation, and it was not fair to the boiler-house that it should be debited with the negative work involved in the heat cycle. To be logical, they must include the boiler feed pump amongst the engine-room auxiliaries, and when they spoke of the net engine-room efficiency the power required by the boiler feed pump must be taken into account. The calculation of the thermal efficiencies of the engine-rooms was clear from the figures given in the table. The only assumption which was made was that the radiation and miscellaneous losses outside the boiler itself, *i.e.*, pipe line losses, drain leakages, &c., had been apportioned equally between the boiler-house and the engine-room as had been done in that paper. Those losses were, in the American stations—except in one case, *i.e.*, Milwaukee—of an order similar to those found at Barton. In separating the performances of the Barton "A" and "B" stations, he thought that the authors had penalised their "B" station unduly

Operation Results of Engine-rooms.

1	2	3	4	5	6	7	8	9	10	11	12
1	Power station		Columbia.	TrentonCh.	Richmond.	Philo.	Philo.	Milwaukee.	Padiham.	Barton A.	Barton B.
	Load Conditions :										
2	Conditions of running of plant		Operation.	Operation.	Operation.	Operation.	Operation.	Operation.	Operation.	Operation.	Operation.
3	Reference		N.E.L.A., June, 1928.	N.E.L.A., June, 1928.	N.E.L.A., June, 1928.	N.E.L.A., June, 1928.		N.E.L.A., June, 1928.	THE ENGINEER July 27th, 1928	*Engineering.* Jan.-Mar., 1926	
4	Date put into operation		1925	1924	Nov., 1925	Sept., 1924	No. 7	H.P., 1926 L.P., 1920–1926	March, 1927	Oct., 1923	Nov., 1928
5	Period covered		Jan, 1927	May, 1927	May, 1927	Oct., 1926	Corrected to full time reheating conditions (2·78% lost due to operating 16% of time without R.H.)	Feb., 1927	Mar., 1928	Nov., 1925	Oct., 1929
6	Installed capacity, kW		90,000	250,000	100,000	80,000		167,000	30,625	82,500	41,000
7	Maximum load (gross), kW		—	—	—	—		—	12,300	60,820	39,600
8	Load factor referred to maximum load (7), %		60·7	56·8	75·6	60·7		52·5	65·66	52·9	68·90
	Steam Conditions :										
9	Average steam pressure at stop valve, lb./sq. in. g.		600	381	391	555		H.P. 1,253 L.P. 285	244	352	360
10	Average steam temperature at stop valve, deg. Fah.		725	692	660	713		702 698	596	651	698
11	Average reheat temp./press. at turbine, ° F./lb./sq. in. g.		720/98	—	—	725/123·8		330/709 —	—	—	—
12	Vacuum/temperature at exhaust, in. Hg./° F.		0·937/77	1·15/83	1·37/88	1·37/89		0·763/71 0·731/70	0·67/67	0·79/71·8	0·86/74·3
13	Cooling water inlet temperature, ° F.		34	56	60·7	57		38·2	46·2	48·7	56
14	Feed temperature, ° F.		222	213	308	214		324 165	120	197	304
15	Adiabatic heat drop, B.Th.U./lb.		590	477	457	564		617 482	453·5	477·9	488·1
16	Total heat in steam to turbine without feed heating, B.Th.U./lb.		1,480	1,309	1,281·5	1,430		1,430·5 1,329	1,285·1	1,303·3	1,325·9
17	Total heat in steam to turbine with feed heating, B.Th.U./lb.		1,335	1,179	1,031·5	1,305		1,286 1,234	1,232·1	1,178·2	1,094·4
	Operation Results :										
18	Actual net heat consumption,* B.Th.U./kWh		12,462	14,540	13,700	14,508		15,077	16,515	16,282	14,545
19	Boiler efficiency at most economical rating, %		89·05	90·0	90·2	86·0		87·2	—	84·9	84·9
20	Boiler operating losses, %		1·05	2·7	3·7	1·79		2·34	—	4·04	5·55
21	Boiler operating efficiency, %		88·11	87·56	86·86	84·46		85·16	80·95†	81·48	80·19
22	Power to auxiliaries, per cent of units generated		5·42	4·9	4·1	4·74		4·95	3·32	5·15	5·05
23	½(−radiation and miscellaneous losses), %		0·95	1·30	0·35	1·00		3·19	—	1·13	1·12
24	100%−[(22)+(23)], %		93·63	93·8	95·55	94·26		91·86	96·8	93·72	93·83
25	Engine-room heat cons. based on units generated, B.Th.U./kWh		10,281	11,942	11,372	11,550	11,230	11,794	12,925	12,432	10,944
26	Engine-roon thermal efficiency based on units generated, %		33·18	28·57	30·00	29·54	30·38	28·93	26·40	27·44	31·17
27	Power to engine-room auxiliaries, inc. boiler feed pump, % of units generated		2·8	2·36	2·60	2·38	2·38	2·29	2·6 (est.)	3·07 (est.)	2·15
28	Net engine-room heat cons., B.Th.U./kWh		10,576	12,230	11,674	11,830	11,502	12,070	13,272	12,826	11,187
29	Net engine-room thermal efficiency, %		32·25	27·90	29·22	28·84	29·66	28·27	25·71	26·60	30·50
	Particulars of Engine-room :										
30	Generating units, capacity		2 tandem 45,000 kW	5 single-cyl 50,000 kW	2 two-cyl. 50,000 kW	2 single-cyl. 40,000 kW		1 7,000 kW 2 20,000 kW 4 30,000 kW	2 7,500 kW 1 15,625 kW	3 single-cyl. 27,500 kW	1 two-cyl. 41,000 kW
31	Feed heaters, number of stages		3	3	3	1 bleeder ht. +1 gland ht.		4 H.P., 1 L.P.	Exh. from aux. engines	1 main turb. +H.S. cond.	4
32	Evaporators		None	Single-stage	Griscom-Russell	4-stage film type		—	None	None	None
33	De-aerators		Heater-de-aerator	None	Cochrane	Open heater		—	None	None	None
	Remarks :										
34	* Including auxiliaries, but excluding transformer losses								† Including radiation and miscl. losses		
	Corrected Result :										
35	Net engine-room thermal efficiency corrected to 350 lb./sq. in. g., 700 deg. Fah. non-reheat, 29in. vacuum, %		29·00	28·09	29·96	—	27·59	27·06	27·27	26·85	30·24

exceedingly fortunate position of having their chairman and a member of the Committee of the North-Western Branch as joint authors that evening. They were credited experts on the subject with which they were dealing, and formed a very happy combination of maker and user of the plant under consideration.

Dr. G. Gerald Stoney, who opened the discussion, remarked that the paper showed what great care was necessary to get reliable results, and he wished such care was always taken. In at least half the tests he knew of there were doubts as to their accuracy. Sir Charles Parsons had pointed out that for large turbines it was best to have the high-pressure and the low-pressure sections separate, so that the high temperature and high pressure were confined to a comparatively small high-pressure cylinder. On the Continent, turbines were divided into three or more cylinders. He joined with the authors in emphasising how much appointed with the boiler-house efficiency. It was given as 80·6, which included half the range losses. He thought that was a low figure for a plant equipped with economisers and air pre-heaters. The stack temperature of 341 deg. on pulverised fuel dust had been referred to by Mr. Lamb, who had explained that the air heater in that case was on the small side. The power used by the auxiliaries in station "B" was very low in comparison with station "A." He did not know why, unless the size of the generating units accounted for it. He congratulated the Barton station on the very wonderful performance it had put up during the last few years. That station had "led the field" in this country for a long period, and the figures were as accurate as figures of that nature could possibly be.

Mr. K. Baumann pointed out that the actual efficiency of the engine room itself could usually not by assuming that the auxiliary power losses were the same in both stations. In the case of the boiler-house auxiliaries, as the heat consumption of engine-room "B" was 15 per cent. less per kilowatt generated than that of engine-roon "A," the boiler-house auxiliary power chargeable in "B" was less in proportion. In comparing the efficiencies of engine-rooms, steam and cooling water conditions might, of course, be taken into consideration, *i.e.*, corrections might be allowed for pressure, total temperature and for the vacuum, but engineers were not, however, in his opinion, entitled to make any correction for feed temperature in spite of what had been said in recent years. It was time they abandoned comparisons on the basis of the Rankine cycle when performances of steam prime movers were concerned, and that they made the comparison on the basis of the regenerative or feed heating cycle, which had

BRITISH RAILWAY RESULTS IN 1929.

BY the continued courtesy of the secretaries of the various railway companies, in sending us their annual reports, we are able to give herewith a table showing the results of working last year, together with the corresponding figures for 1928. We submit the figures exactly as they appear in the reports. Explanations could be offered for various increases and decreases, but it seems desirable not to attempt anything of that nature, as much would be only conjecture. We would, however, remark that, as last year, in the engineering details in Table II. no deductions or additions have been made for transfers to or from reserve funds; the figures are the amounts actually spent.

TABLE I.—*Receipts and Expenditure.*

	London, Midland and Scottish.		London and North-Eastern.		Great Western.		Southern.		Four grouped companies.	
	1929.	1928.	1929.	1928.	1929.	1928.	1929.	1928.	1929.	1928.
Receipts :	£	£	£	£	£	£	£	£	£	£
From railway working, passenger	28,722,807	29,779,779	19,097,093	19,584,971	12,761,195	13,059,007	16,969,015	17,133,575	77,570,110	79,557,332
From railway working, freight	43,816,074	43,410,102	35,985,015	34,039,688	17,976,977	17,177,442	5,742,581	5,597,625	103,520,647	100,224,857
From railway working, miscellaneous	656,383	680,191	478,985	488,204	270,303	249,171	280,913	288,191	1,686,584	1,705,757
From railway working, total	73,195,264	73,870,072	55,561,094	54,112,863	31,028,475	30,485,620	22,992,509	23,019,391	182,777,342	181,487,946
From other businesses	8,466,784	8,397,991	7,734,361	7,311,096	5,153,578	5,041,924	3,514,509	3,497,504	24,869,232	24,238,515
On whole undertaking, total	81,661,048	82,258,063	63,295,455	61,423,959	36,184,053	35,527,544	26,507,018	26,516,895	207,647,574	205,726,461
Expenditure :										
On railway working, way and works	7,675,107	7,761,550	6,015,405	5,988,345	4,046,379	4,018,905	3,473,733	3,391,613	21,210,624	21,160,413
On railway working, rolling stock	10,288,804	10,052,896	8,938,503	8,501,899	4,116,180	4,082,341	2,916,606	2,900,235	26,260,093	25,537,371
On railway working, locomotive running	14,078,362	14,219,642	10,418,656	10,262,755	5,522,955	5,534,088	4,203,304	4,289,132	34,223,277	34,305,617
On railway working, traffic	20,815,796	21,290,694	14,653,196	15,098,364	8,144,060	8,186,621	5,691,270	5,773,454	49,304,322	50,349,133
On railway working, general	5,304,994	5,616,753	3,256,870	3,479,795	2,478,967	2,654,491	1,889,593	2,092,568	12,930,424	13,843,607
On railway working, total	58,163,063	58,941,538	43,282,641	43,331,158	24,308,541	24,476,445	18,174,507	18,447,002	143,928,752	145,196,143
On other businesses	8,715,303	8,517,024	7,612,872	7,406,971	4,900,250	4,931,726	2,739,742	2,696,109	23,968,167	23,551,830
On whole undertaking, total	66,878,366	67,558,562	50,895,513	50,738,129	29,028,791	29,408,172	20,914,249	21,143,111	167,716,919	168,847,974

TABLE II.—*Details of Main Items of Engineering Expenditure.*

Way and Works :										
Roads, bridges and works	952,061	998,727	790,061	859,439	816,035	543,550	517,776	505,926	3,075,933	2,898,642
Permanent way	4,589,475	4,634,700	3,364,343	3,578,810	2,178,329	2,208,952	1,936,603	1,961,277	12,068,750	12,383,739
Signalling	633,715	607,780	570,456	584,411	322,157	342,896	350,676	441,320	1,877,004	1,976,407
Telegraphs and telephones	193,917	176,808	140,876	146,624	95,521	89,889	83,389	56,227	513,703	469,548
Electric track equipment	30,165	33,100	13,773	17,677	1,412	2,421	201,270	690,359	246,620	743,557
Buildings	1,178,102	1,145,923	750,077	839,310	534,957	528,508	630,650	517,188	3,093,786	3,030,929
Rolling Stock :										
Locomotives	4,914,463	5,260,532	3,981,855	4,150,287	2,456,583	2,254,809	1,028,033	1,072,306	12,380,934	12,737,934
Electric rail motor vehicles	184,483	131,451	25,942	18,943	6,603	6,022	466,026	596,202	683,054	752,618
Coaching stock other than above	2,860,129	2,461,782	2,247,113	2,063,277	1,057,416	1,078,830	951,041	938,934	7,115,699	6,542,823
Wagons	2,896,440	2,637,785	2,563,213	2,845,896	651,945	716,413	364,587	433,188	6,476,185	6,633,282
Locomotive Running :										
Wages, steam trains	8,081,057	8,267,455	6,470,745	6,454,254	3,531,811	3,515,353	1,892,709	1,952,526	19,976,322	20,189,588
Fuel, steam trains	4,808,669	4,743,324	3,624,686	3,415,939	1,760,440	1,791,541	1,367,749	1,423,184	11,561,544	11,373,988
Wages, electric trains	81,529	81,398	16,811	15,592	3,888	4,266	155,439	142,416	257,667	243,672
Current, electric trains	340,381	369,917	43,203	42,465	37,251	38,472	566,954	542,624	987,789	993,478

fully justified itself and had become established practice, at least in stations of the size under discussion. There were certain difficulties in making the comparison on a purely theoretical basis with an infinite number of feed heaters, and he suggested that the data which had been published by one of the authors for four-stage feed heating formed an accurate as well as a convenient basis for comparison.

Major Thompson said the authors had not given fancy figures with regard to the boiler section of the paper. He believed his firm had, under various conditions, managed to satisfy the station engineer for a few hours and had got 90 per cent. efficiency; but the figures the authors had given were for long periods, and he was impressed by the time and money spent in getting the figures accurate.

Mr. Bayliss said, with regard to pulverised fuel firing and the stoker firing figures, he thought that was the first case within his knowledge where comparative figures had been given on the two classes of firing. The one difficulty in making an accurate comparison was the temperature of the outlet gases, which Mr. Lamb had explained. The site available was limited in height, and it had not been possible to introduce as large air heater surface as one would have desired, but if they assumed that sufficient air heater surface could have been introduced to have brought the exit gases leaving the chimney to the same temperature as obtained through the stoker firing boiler, they would have obtained an efficiency of 80·5 as against the stoker-fired figure of 80. He believed that the pulverised fuel boiler would have shown up to better advantage had it been operated on a lower grade fuel.

Dr. T. Petrie remarked that the authors had given in some detail not only a description of the economiser leakages, but had mentioned three reasons which might account for them. A fourth reason might have been taken into consideration, namely, the possible variation in hydraulic pressure whenever the load was run up or down. The normal pressure in the economiser was higher than that in the boiler, 410 lb. per square inch, as against 375 lb. per square inch, and there was always a possibility of between 30 lb. and 40 lb. per square inch excess pressure here, depending on the characteristic of the feed pumps. Presumably, there had been no trouble of a similar nature in the boiler plant, as no mention was made of it in the paper, and any satisfactory explanation should take this absence into account. There was no doubt that leakage at an economiser joint was more apt to cause wasting and trouble than leakage of a similar order at a boiler joint. There was a lower concentration of salts in such leakage, also the flue gases were nearer the dew point, and, in consequence, such leakages would not dry up so rapidly; thirdly, the weaker acid solution possible under such conditions was a more active corroding agent.

Mr. Midgley said there were one or two minor questions he wished to raise. On boilers Nos. 11 and 12—stoker-fired boilers—the cubic capacity of the combustion space per square foot of grate area worked out at 9·5. That, in comparison with their own practice on more recent plant, was rather on the low side; 14 cubic feet per square foot of grate surface was used in every instance in their practice. He wondered whether, if the stoker-fired boilers were built with larger combustion chambers in proportion to grate area, higher efficiencies would be obtained. He also wondered whether they had not unduly penalised stokers by putting the boiler tubes too closely on to them. He had figured out at normal load the rating of stokers, and found 30 lb. of coal per square foot per hour to be normal. It was stated that the vacuum in station "B" was 29, whereas in station "A" it was 29·1. He assumed that the lower vacuum was found to be more economical with the given cost, and the given load factor. He also noticed that at overload the feed temperatures all the way through were higher than the normal rating, but at the last stage the temperatures were the same—300 deg. Fah. Was that done by controlling the steam for the heater in order to maintain constant conditions in the boiler-house, or was there any other reason? Furthermore, was oil required for starting up the pulverised coal boilers, and, if so, had the equivalent amount of oil been included in the amount of coal for starting up?

Mr. Clark said the comparison between the pulverised fuel boiler and the stoker-fired boiler was scarcely fair. Mr. Lamb had given the heating surface of the air heater as being very much less in the case of the pulverised fuel boiler than in the case of the stoker-fired boiler. Even under those conditions, the results obtained were practically the same. In making that comparison, the point had not been emphasised that the heating surface of the pulverised fuel boiler was considerably less than that of the stoker-fired boiler, while, according to the results obtained, the work done per unit of heating surface in the pulverised fuel boiler was at least equal to the other. In comparing the economisers, the same thing would be found; so that the whole comparison justified the conclusion that the pulverised fuel boiler was the more efficient. Mr. Lamb had said that in order to warrant the installation of pulverised fuel, it was necessary that the pulverised fuel boiler should have an efficiency of 2 per cent. more than the stoker-fired boiler. No doubt, Mr. Lamb was speaking from facts, and, in the case in point, he must have meant the cost of the pulverised fuel boiler was greater than the other. Mr. Guy had mentioned starting up and banking losses. In starting up a pulverised fuel boiler there was certainly a little loss, but it did not compare with the loss in starting up a stoker-fired boiler.

Mr. W. Eccles said he had no doubt that when the Electricity Commissioners realised the full importance of the authors' work, they would set in motion the necessary machinery to collect and publish similar data from all the modern stations, and so make it unnecessary for the engineers of other countries to go to the N.E.L.A. reports on American practice for their information. He wished the authors could have seen their way to publish also the £ s. d. side in a similar manner. Anyone who cared to look up the data published by the *Electrical Times* would find that the coal cost was only a comparatively small proportion of the cost price to the consumer; in the case of Manchester, coal costs were about 15 per cent. of the total cost of electricity to the consumer. He did not in the least intend to deprecate efforts spent in an attempt to reduce coal costs, but he did deprecate the whole of their efforts being directed in any one channel to the exclusion of all others, and he was afraid that that was what had happened since the inception of the Electricity Commissioners, and was directly due to the periodical returns published by them, which arranged stations in the order of their coal consumption only.

Mr. V. Walker considered the exit temperature of 640 deg. Fah. for the powdered fuel boiler to be rather high. The heat transmitted per square foot of heating surface per hour by the economiser was in the neighbourhood of 1700 B.Th.U., which figure was excessive, being about twice the rate of heat transmission of the older type of economiser. If, by a rearrangement of the boiler baffling, the temperature at boiler exit was reduced to, say, 570 deg. Fah., the economiser would have less work to do. The rise in temperature of the water in the economiser would drop from 78 deg. to 64 deg. Fah., which represented a loss in efficiency of approximately 1·2 per cent. The heat would, however, be better employed in the boiler section, the third pass of which was probably doing only a very small proportion of the work. In the case of the stoker-fired boiler, the boiler exit temperature was again on the high side, the rate of heat transmission in that case being 1000 B.Th.U. per square foot per hour. It was sometimes an advantage, say, in the case of the horizontal type of economiser, to increase the velocity of the gases by closing the spaces between the sections, thereby obtaining a better heat transmission. He was particularly interested in the corrosion of the tubes of the economiser sections. In 1921 they had installed two 50,000 lb. per hour boilers with steel economisers. The boilers were of the four-drum vertical straight tube type, the fourth section forming an economiser. After about two months' run, the economiser was found to be corroded very severely. Zinc plates were fitted, and various paints tried out on the plating of the drums. These had no effect. After experiments, they had found that the feed water oxygen content varied from 3–4 c.c. per litre. A de-aeration plant had then been installed, which brought that down to ·1 c.c. per litre. It had also been found that by heating up the condensate by the aid of live steam to the hot well and before it entered the de-aerator, the oxygen content had been reduced to ·05 c.c. per litre.

Mr. H. C. Lamb, in reply to the discussion, said that Mr. Adams had referred to the high temperature of 300 deg. of the feed water supplied to the boiler-house. The reason for that had, he thought, been made clear. It was because of the need for economising in circulating water. The electrical output from the new plant was 30 per cent. greater than the

output from the old plant, but, owing to the large amount of steam used for feed heating, there was only 10 per cent. more steam to go to the condenser. He had been much interested in Dr. Petrie's suggested fourth theory for the possible explanation of the trouble on the economisers, but he should have made it clear that the boiler feed pumps were all rotary feed pumps, and that they had a very flat characteristic. There was no excessive rise of pressure under normal working conditions. They had come to the conclusion, after considering that theory, that that could not be the real explanation. Mr. Midgley had mentioned the question of the reason why the vacuum had been reduced from 29. That was a question of circulating water. They had been saving in that way and at the same time there was a saving in the capital cost of the plant. Oil had not been used for starting up purposes, and was therefore not included. Mr. Clark's assumption that he had not got very exact figures for the comparative cost of pulverised fuel and stoker-fired boilers was correct. Undoubtedly, pulverised fuel had a great advantage in operating, and if the cost of the plant were identical, then pulverised fuel would have a much better chance, even in Lancashire.

Mr. H. L. Guy, in reply to the discussion, said that Dr. Stoney had raised a very important point when he had stressed the importance which should be attached to the skilled superintendence of a power station in the results which were achieved. He agreed with Mr. Adams that de-aerators had no place in a modern power station, but he would suggest that when the oxygen content was very low it was practically impossible to say that one result was better than another. He did not think Mr. Adams was quite as conservative in regard to feed heating as they might imagine. In spite of the very excellent results he had obtained in his Padiham power station, he had gone a step further with feed heating in his new station. One point Mr. Midgley had mentioned was interesting, because during the process of developing the system of station performance analysis they had been faced with the difference in the possible form of the load curves. If a form load factor could be devised, it might be a useful criterion to be added in assessing the relative merits of station performance figures.

Operating Results with the Recent Extensions at Barton Power Station.*

By H. L. GUY and H. C. LAMB.

Introduction.

The original Barton power station was commenced in 1920, and was described in a paper read by H. N. Allott, M. Inst. C.E., and S. L. Pearce, C.B.E., M.Sc., M. Inst. C.E., before the Institution of Civil Engineers on April 15th, 1924.

By 1926 it became necessary to provide additional plant. In this paper the authors hope to show the main differences in design and performance between the earlier and later plants

Boilers.

The new boiler-house, which is approximately 90ft. high, 50ft. long and 50ft. wide, lies adjacent to the bunker bay of the original boiler-house, and local screw conveyors carry the coal direct from the old bunkers to the new boilers. The new boiler plant consists of three units, numbered 10, 11 and 12 respectively. The first of these is fired by pulverised fuel, while the remaining two have chain grate stokers.

The main particulars of the new boilers, together with those of the original boilers—Nos. 1 to 9—are given in Table I.

Table I.—*Schedule of Boiler Particulars.*

Boiler numbers	10	11 and 12	1–9
Furnace—			
Firing	Pulverised	Stokers, Two 13ft. × 20ft.	Stokers, Four 8ft. × 16ft.
Grate area, sq. ft.	—	520	512
Combustion space, cu. ft.	9,760	4,930	Two 1,870
Construction of walls	"Bailey"	"Lulof"	Refractory brick
Wall face area, sq. ft.	1,370	814	—
Heating surfaces—			
Wall tube surface, sq. ft.	2,327	485	—
Slag screen surface, sq. ft.	623	—	—
Boiler surface, sq. ft.	13,235	18,487	16,020
Superheater surface, sq. ft.	4,150	4,860	6,072
Economiser surface, sq. ft.	5,010	6,750	11,800
Air Heater surface, sq. ft.	19,439	28,470	12,080
Steaming characteristics–			
At superheater outlet, pressure, lb. per sq. in.	375	375	375
Temperature, deg. Fah.	730	730	730
Normal evaporation, lb. per hour	130,000	130,000	100,000
Maximum evaporation, lb. per hour	170,000	150,000	120,000
Average steam for soot blowing, lb. per hour	1,650	1,500	1,500
Auxiliaries—			
Induced draught fan, H.P.	200	185	95
Forced draught fans, H.P.	2 × 48	2 × 56	68
Two Fuller-Bonnot mills, H.P.	2 × 75	—	—
Exhauster for ditto, H.P.	2 × 35	—	—
Capacity, lb. per hour	2 × 8,000	—	—
One 54in. Lehigh mill, H.P.	120	—	—
Exhauster for above, H.P.	50	—	—
Capacity, lb. per hour	15,000	—	—
Stoker motors, H.P.	—	Two 4½	Group driving
Manufacturer	B. and W.	B. and W.	B. and W.

The pulverised fuel unit was originally installed with a water-cooled furnace, constructed on the "Lulof" principle, in which the tubes are protected with specially

Fig. 1—Eroded Economiser Tubes

shaped refractory tiles. The method of firing used was the bin and feeder system, by means of five vertical burners, with two horizontal burners in each side wall. When certain operating difficulties were experienced with this experimental installation it was decided to remodel it in the "unit" principle. The reconstruction of the furnace on the "Bailey" wall system permitted much greater heat liberation per unit volume, and although the actual furnace volume was reduced, its effectiveness was considerably increased. Horizontal turbulent burners were fitted, which also added to the furnace efficiency. To overcome the trouble of "birdnesting" originally experienced in the lower rows of boiler tubes, a separate slag screen was provided across the full width of the furnace, constructed in such a manner as to form at its front an arch of "Bailey" construction. As the presence of existing steel work rendered the introduction of water cooling at the front of the furnace impossible, this wall was built of high-grade refractory. The furnace is now fired by means of four "Lodi" turbulent burners fitted in the front wall and designed to give a reasonably short flame travel. The side and rear walls have Bailey blocks of refractory material in the combustion zone, but in the zone of moderate heat immediately above rough cast iron blocks are provided, which hold the slag and thus form their own refractory. In the cool zone around the top of the wall, in the ash hopper and where walls abut, smooth cast iron blocks are used which prevent the accumulation of slag. The walls of this furnace are supported from the bottom and the "Bailey" method of re-circulation has been adopted. The ash hopper is fitted with a hydraulically operated gate and a water spray to facilitate ash handling. For supplying the wing burners two "Fuller-Bonnot" mills are installed, each fitted with a separate exhauster and variable-speed exhauster fan. These are slow-speed tube mills, with internal classifier and external separator and are practically noiseless in operation. The two centre burners are supplied by a single 54in. Lehigh mill, delivering 15,000 lb. of pulverised fuel per hour. When dealing with abnormally wet fuel a percentage of furnace gas can be drawn from the zone immediately above the slag screen and passed into the pulverising mills. The boiler is equipped with a cyclone grit arrester, while the soot blowers are of the calorised diamond valve-in-head type.

Boilers 11 and 12 are of the cross-drum marine design, having inclined headers in contrast to the vertical stepped pattern of No. 10 boiler, while firing is carried out by means of chain-grate stokers. A portion of the side walls and the rear wall is provided with water cooling tubes and walls of the "Lulof" type. The stoker arches are of the suspended Liptak type. Each stoker is independently driven and fitted with clinker slicing links.

Boiler Tests.—The primary reason for the installation of No. 10 boiler as a powdered fuel unit was to provide an opportunity for direct comparison of the efficiency and convenience of operation of this form of firing with that of stoker firing.

Careful tests have been made, therefore, on the powdered fuel unit No. 10, and also on a stoker-fired unit No. 11, under ordinary working conditions over an extended period. Both units were in good clean condition, and no special steps were taken to ensure an unusually high efficiency.

The coal burned during test was a dry Lancashire slack of fairly uniform quality and of approximately 11,500 B.Th.U. calorific value. It was weighed into the bunkers and again at the boiler chutes in the case of No. 10 boiler. The difference in results given by the two methods was only 0·72 per cent., so the mean was used for calculation. The coal for No. 11 boiler was wetted as it left the bunker in order to give better combustion on the grates. The weight shown by the automatic scales on the boiler chutes was taken for the purpose of the test. In the case of the pulverised fuel unit, hourly samples of approximately 5 lb. were taken from the north and south side mills, respectively, and the two aggregate samples were reduced and analysed every twenty-four hours. A similar procedure was adopted in the case of No. 11 boiler, hourly samples of 10 lb. being taken from each stoker. In both cases, therefore, the weights and analysis truly represent the condition of coal as fired.

In calculating the average calorific values the figures

Table II.—*Comparative Tests on Pulverised Fuel and Stoker-fired Boilers, Barton Power Station.*

Test on boiler No.	10	11
General—		
Method of firing	Pulverised fuel	Stokers
Date of test	December 6th–13th, 1929	February 8th–12th, 1930
Duration of test, hours	168	103
Fuel—		
Total fuel fired, lb.	2,293,300	1,514,700
Average fuel fired per hour, lb.	13,650	14,700
Average proximate analysis—Moisture, per cent.	4·88	10·28
Volatile matter, per cent.	27·8	29·5
Fixed carbon, per cent.	54·9	55·0
Absolute ash, per cent.	17·3	15·5
Total, per cent.	100·0	100·0
Average gross calorific value as fired, B.Th.U. per lb.	11,450	11,114
Water—		
Total evaporated from feed water meter, lb.	18,797,000	12,785,240
Average evaporation per hour, lb.	111,890	124,130
Average temperature of feed to economiser, deg. Fah.	230	304
Average temperature of feed to boiler, deg. Fah.	308	359
Steam—		
Average steam pressure, lb. per sq. in. gauge	380	373
Average temperature of superheated steam, deg. Fah.	711	710
Average heat input per pound above feed temperature, B.Th.U.	1,176	1,102
Total steam used for soot blowing (estimated), lb.	238,000	154,500
Ash—	Ashpits. Grit arrester.	Ashpits. Grit arrester.
Total dry ash, lb.	127,000 .. 49,730	199,584 .. 1,800
Dry ash per cent. of fuel burned	5·54 .. 2·17	13·2 .. 0·12
Average combustible in ash, per cent.	2·0 .. 19·5	4·4 .. 26·0
Flue gases—		
Average CO_2 at boiler outlet (by volume), per cent.	14·9	(Econ. outlet) 12·1
Average temperature leaving boiler, deg. Fah.	640	632
Average temperature leaving economiser, deg. Fah.	407	482
Average temperature leaving air heater, deg. Fah.	341	301
Air—		
Average temperature of cold air to heater, deg. Fah.	95	100
Average temperature of hot air leaving heater, deg. Fah.	—	257
Average temperature of air to mills, north, deg. Fah.	206	—
Average temperature of air to mills, south, deg. Fah.	294	—
Auxiliary power—		
Average consumption of forced draught fans per hour, kW-hours	48·8	170
Average consumption of induced draught fans per hour, kW-hours	140·0	170
Average consumption of pulverising mills and exhausters per hour, kW-hours	171·2	—
Average total consumption of auxiliaries per hour, kW-hours	360·0	170
Average total consumption of auxiliaries per lb. of fuel fired, kW-hours	0·0264	0·0115
Conversion factor, B.Th.U. in coal per kW-hour auxiliary power	15,150	15,150
Deductions—		
Water evaporated per lb. of fuel fired, lb.	8·20	8·44
Fuel fired per square foot of grate per hour, lb.	—	28·3
Heat balance—	B.Th.U. Per cent.	B.Th.U. Per cent.
Heat transferred to water in boiler per lb. of fuel	7,720 .. 67·4	7,520 .. 67·7
Heat transferred to steam in superheater per lb. of fuel	1,280 .. 11·2	1,320 .. 11·9
Heat transferred to water in economiser per lb. of fuel	640 .. 5·6	460 .. 4·1
Gross efficiency of unit	9,640 .. 84·2	9,300 .. 83·7
Heat carried away by dry products of combustion	610 .. 5·3	680 .. 6·1
Heat lost by unburnt carbon in ashes	280 .. 2·4	84 .. 0·8
Heat lost by heating steam formed by hydrogen	425 .. 3·7	420 .. 3·8
Heat lost by evaporation and superheating free moisture in fuel	58 .. 0·5	120 .. 1·1
Heat lost by radiation, hot ashes, &c. (by difference)	437 .. 3·9	510 .. 4·5
Total gross calorific value of fuel	11,450 .. 100·0	11,114 .. 100·0
Power used for auxiliaries	400 .. 3·5	175 .. 1·6
Steam used for soot blowing	122 .. 1·1	150 .. 1·2
Net efficiency of unit	9,118 .. 79·6	8,975 .. 80·9

* Institution of Mechanical Engineers, North-Western Branch, March 20th, 1930—Abridged.

were in all cases proportioned according to the weight of coal represented by each. The daily proximate analyses varied very little and a simple average of the figures was therefore taken in this case. The feed water to the boilers was measured by a Kent Venturi recorder which had been carefully checked, and the throat re-calibrated in June, 1929. Ash and grit were trucked to the station weigh-bridge, where their weights were recorded.

Samples of 20 lb. from the ashpits and 5 lb. from the grit arresters were taken every six hours, and the aggregate samples were reduced and analysed every twenty-four hours.

From the results given in Table II. it will be seen that the gross efficiency of the pulverised fuel unit is 84·2 per cent., while that of the stoker-fired boiler is 83·7 per cent. After deductions have been made for the heat equivalent of the power used by auxiliary motors and the steam used for soot blowing, the resulting net efficiencies are 79·6 per cent. and 80·9 per cent. respectively. Hence it would appear that when burning the normal fuel received from collieries within a few miles of the station there is no economy in pulverising.

It should be pointed out, however, that the stoker-fired unit contains 32 per cent. more heating surface than the pulverised fuel unit, and this clearly has an effect on the relative efficiencies.

Boiler-house Maintenance.

A well-equipped laboratory forms an important part of Barton power station and is capable of accurate analysis and testing of fuels, water, oils and metals. Feed water is tested daily for oxygen content and alkalinity, hence any air leak is discovered promptly and any faults can be remedied before corrosion results. The oxygen content is kept below 0·1 c.c. per litre. The concentration in boiler drums is watched and kept well below the danger point of 100 grains of dissolved solids per gallon of water. The chemist is also responsible for the control of feed water treatment.

Feed Water Treatment.—The Barton make-up water, which amounts to about 3½ per cent., is taken from the Thirlmere main—a source of very pure water. In the early life of the station the only treatment adopted was the addition of caustic soda to make the water slightly alkaline. However, a thin scale containing 94 per cent. calcium sulphate derived from the water formed in the tubes and one or two cases of blistering were experienced. Barium hydrate was thereupon adopted as the alkaline agent, and was quite successful in preventing both corrosion and scale formation.

The question of caustic embrittlement of steels, moreover, came to the fore at this time, and it was decided that any possibility of boiler deterioration on this account should be avoided. Barium hydrate eliminates the sulphate in the water, so that the ratio sulphate to caustic soda is finally reduced to zero, a condition generally considered liable to cause caustic embrittlement. After much experiment it was decided to discontinue the use of barium hydrate on this account, and to adopt tri-basic sodium phosphate, with a small proportion of caustic soda, as the neutralising agent. Under this treatment the sulphate to caustic soda ratio is maintained at about 3·0, sodium sulphate being added when there is a danger of the ratio falling below this figure. This treatment is still in use and has been highly successful.

Condition of Boilers.—Very little trouble has been experienced with the boiler drums and tubes, and they are in excellent condition as far as freedom from scale is concerned. Some corrosion takes place in the economiser tubes, nipples and headers. The rate of attack is very slow, however, and no tubes have been replaced because of internal pitting or wasting, though the older boilers have been in service six years.

Very considerable trouble has, however, been experienced on the older units due to leakage at the economiser tube ends. The trouble has been largely confined to the original double-ended boilers. Particulars of the economisers are given below :—

Diameter of tubes	4in.
Temperature of inlet water ..	200 deg. Fah.
Temperature of outlet water ..	290 deg. Fah.
Temperature of inlet gases ..	560 deg. Fah.
Temperature of outlet gases ..	370 deg. Fah.
Working pressure of boilers.. ..	375 lb. per sq. in.
Working pressure of economisers..	410 lb. per sq. in. max.
Material of headers	Cast steel

Description of Leakages.—The faulty tubes when cut out show a groove across the face of the joint between tube and header—Fig. 1. In the formation of a joint the end of the tube is cleaned down to the metal and is then expanded

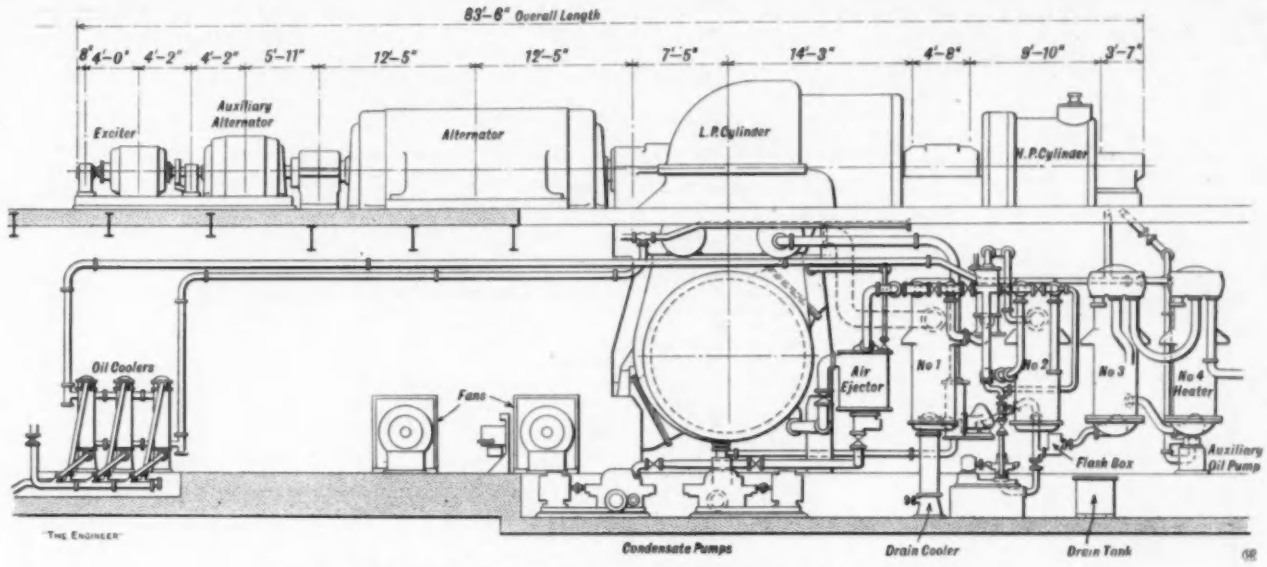


FIG. 2—GENERAL ARRANGEMENT OF TURBO-ALTERNATOR AND FEED HEATERS

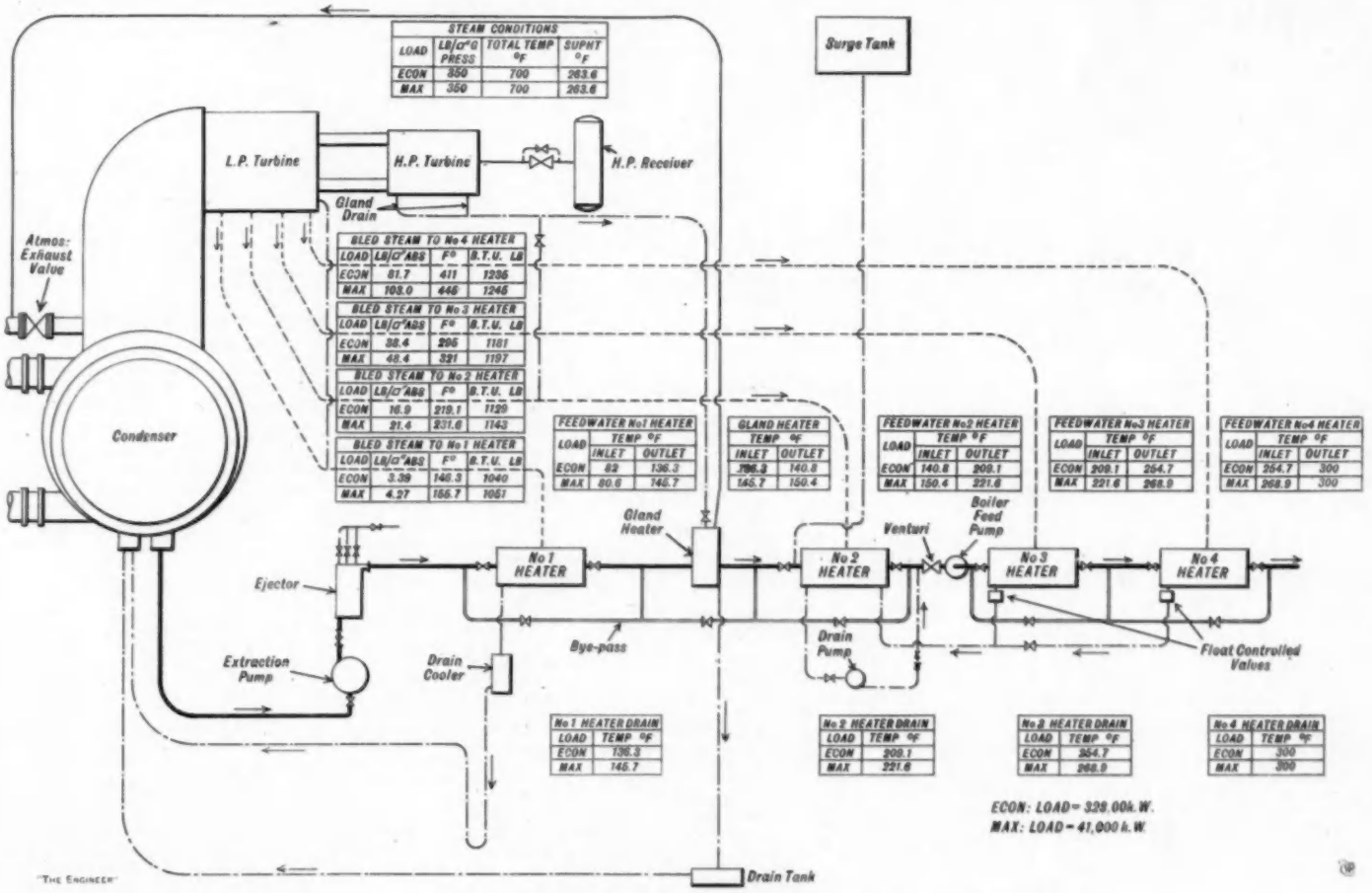

STEAM CONDITIONS
LOAD | LB/□"G PRESS | TOTAL TEMP °F | SUPHT °F
ECON | 350 | 700 | 263.6
MAX | 350 | 700 | 263.6
Surge Tank
L.P. Turbine
H.P. Turbine
H.P. Receiver
Gland Drain
Atmos: Exhaust Valve
Condenser
BLED STEAM TO No 4 HEATER
LOAD | LB/□"ABS | F° | B.T.U. LB
ECON | 81.7 | 411 | 1236
MAX | 103.0 | 446 | 1245
BLED STEAM TO No 3 HEATER
LOAD | LB/□"ABS | F° | B.T.U. LB
ECON | 38.4 | 295 | 1181
MAX | 48.4 | 321 | 1197
BLED STEAM TO No 2 HEATER
LOAD | LB/□"ABS | F° | B.T.U. LB
ECON | 16.9 | 219.1 | 1129
MAX | 21.4 | 231.6 | 1143
BLED STEAM TO No 1 HEATER
LOAD | LB/□"ABS | F° | B.T.U. LB
ECON | 3.39 | 146.3 | 1040
MAX | 4.27 | 156.7 | 1051
FEEDWATER No1 HEATER
LOAD | TEMP °F INLET | TEMP °F OUTLET
ECON | 82 | 136.3
MAX | 80.6 | 146.7
GLAND HEATER
INLET | OUTLET
136.3 | 140.8
145.7 | 150.4
FEEDWATER No2 HEATER
LOAD | TEMP °F INLET | TEMP °F OUTLET
ECON | 140.8 | 209.1
MAX | 150.4 | 221.6
FEEDWATER No3 HEATER
LOAD | TEMP °F INLET | TEMP °F OUTLET
ECON | 209.1 | 254.7
MAX | 221.6 | 268.9
FEEDWATER No4 HEATER
LOAD | TEMP °F INLET | TEMP °F OUTLET
ECON | 254.7 | 300
MAX | 268.9 | 300
Gland Heater
Venturi
Boiler Feed Pump
No 1 HEATER
No 2 HEATER
No 3 HEATER
No 4 HEATER
Ejector
Extraction Pump
Drain Cooler
Bye-pass
Drain Pump
Float Controlled Valves
No 1 HEATER DRAIN
LOAD | TEMP °F
ECON | 136.3
MAX | 146.7
No 2 HEATER DRAIN
LOAD | TEMP °F
ECON | 209.1
MAX | 221.6
No 3 HEATER DRAIN
LOAD | TEMP °F
ECON | 254.7
MAX | 268.9
No 4 HEATER DRAIN
LOAD | TEMP °F
ECON | 300
MAX | 300
ECON: LOAD = 329.00k.W.
MAX: LOAD = 41,000 k.W.
Drain Tank
"The Engineer"

FIG. 3—DIAGRAM OF FEED HEATING SYSTEM

against the header seating. This results in a slight belling effect of the tube wall at both sides of the joint. After leakage has taken place small pit holes are found at the belled portions on either side of the expanded area, and it almost appears as though corrosive attack had eaten into the edge of the joint on the water side. The area of the joint shows no pitting, but is almost invariably black and oxidised. The deep groove is doubtless due to the cutting action of water, and is not representative of the conditions at the time when leakage first commences.

Various explanations have been put forward from time to time to explain the reason for these leakages, thus :—

(*a*) Faulty expansion of the tubes in the headers was considered a possible explanation in the early life of the plant, as peculiar minute wavy channels were often found on the area of the tube which had been expanded against the header seating.

(*b*) When it was found that the leakage mainly occurred at the ends of the tubes where the feed water entered, corrosion was thought to be a possible explanation. In the early stages of the operation of the economiser the oxygen content was higher than it should have been, but by continual effort this has been reduced to approximately 0·08 c.c. per litre in 1929. The leakages have not, however, diminished with decreasing oxygen content, and one is led to believe that other factors are responsible for the trouble.

(*c*) It has also been suggested that unequal expansion with possible movement of the tube relative to header may be responsible for the leakages, but there is no evidence that definitely supports this theory.

Micro-examinations have been made of specimens of the tube ends adjacent to point of leakage. It has been found that the metal of which the tubes are composed is a good quality mild steel of about 0·15 per cent. carbon content. The authors hope that information arising from the discussion will give them some help in an obscure and rather serious problem.

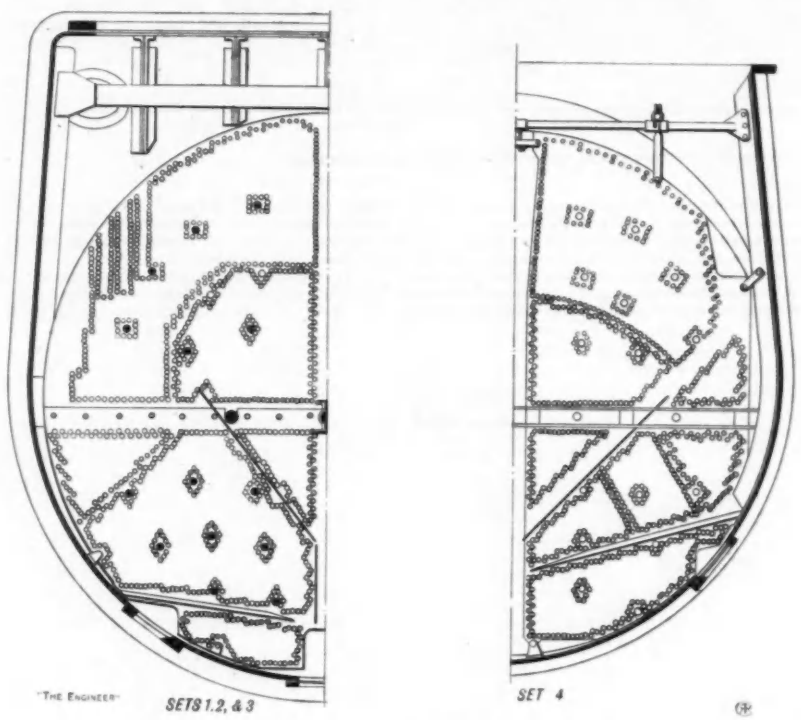


FIG. 4—COMPARISON OF CONDENSER TUBE ARRANGEMENTS

Description of Turbo-generator Sets.

The general particulars of the turbines in engine-rooms A and B are given in the following schedule :—

Table III.

	Station. A.	Station. B.
Maximum continuous rating (main + auxiliary) generators, kW	27,500	40,000 + 1000
Economic rating (main + auxiliary) generators, kW	25,000	32,000 + 800
Pressure before stop valve, lb. per sq. in. gauge	350	350
Temperature before stop valve, deg. Fah.	700	700
Designed vacuum at economical rating (32 deg. Fah. and 30in. bar.), in. Hg.	29·1	29
Number of regenerative feed heater stages	1 (house turbine)	4
Final temperature leaving feed heaters at economic rating, deg. Fah.	200	300
Number of cylinders of turbine	1	2
Number of stages of turbine	12 + duplex multi-exhaust	H.P. = 23 L.P. = 16 + duplex multi-exh't.
Number of wheels	14	H.P. = 23 L.P. = 18
Mean diameter H.P. blading	7ft.	3ft. 6in.
Tip diameter last wheel	9ft.	10ft. 2⅜in.
Number of thrust bearings	1	2
Manufacturer	Metropolitan-Vickers Co.	Metropolitan-Vickers Co.

In the earlier machines the initial expansion took place in a velocity wheel, and overloads were obtained by opening up an increased arc of admission so that the maximum pressure in the turbine cylinder was only a fraction of that before the stop valve. In the new machine the early stages of expansion occupy a relatively large number of low velocity stages and overloads are obtained by by-passing an appropriate number of these stages, so that at maximum load the pressure in the high-pressure end of the cylinder is within 10 per cent. of that before the stop valve. Both sets of turbines are single-flow impulse type, and both are characterised by the multi-exhaust construction of the last stage.

When engine-room A was first put into operation the turbine and generators were coupled by a solid coupling. At an early stage certain variation in quality of balance and sensitiveness in starting up was associated with the rigidity of this coupling. These difficulties were eliminated by replacing the solid coupling with an elastically flexible coupling. This feature has been retained between the turbine and the generator in the new set. As both the high-pressure and low-pressure rotors have their own thrust blocks, it is necessary to allow freedom of axial expansion for both. This is accomplished by coupling them with a Wellman-Bibby coupling.

While the single-stage regenerative feed heater of the turbines in engine-room A were integral with the main turbine casing and were placed on the suction side of the feed pump, those of the set in engine-room B are separate from the turbine casing, the last two being on the discharge side of the boiler feed pump. In the event of tubes bursting, the feed heaters are protected against flooding by floats operating by-pass valves through relays.

The general arrangement of the feed heating system in engine-room B is shown in Fig. 2. A diagrammatic arrangement giving the distribution of pressure and temperature at various loads is shown in Fig. 3.

The vertical arrangement of the feed heaters allows them to be placed right against the turbine foundation block. In this way direct access to the crane is provided, which, coupled with the fact that all lifts are stable, makes handling a far simpler matter than with the horizontal arrangement of the earlier sets. Further, all feed heater control valves are visible at one place, and the arrangement of the whole in its relation to the main turbine is such that the purpose of each part is immediately obvious.

The efficiency of the new turbine, relative to adiabatic expansion, is 8½ per cent. better than that of the main turbines in engine-room A, while the overall thermal efficiency of the main turbine and regenerative feed heaters in engine-room B is 12 per cent. greater than that in engine-room A.

An obvious change in design lies in the adoption of two cylinders to accommodate the relatively large number of stages into which the expansion is divided. Much of the improvement in efficiency and the ease with which the plant can be handled is due to this departure. The main alternator is designed for an output of 50,000 kVA at 6600 volts. The stator core is built up of silicon alloy iron and is arranged with vent spaces of the smooth core type that provide a smooth surface for the conductors. These are bakelised and slide in the vents, thus allowing free thermal expansion to take place. The stator is clamped by solid copper end plates of the radial squirrel-cage type, which are designed to neutralise the leakage field of the stator end connections. The rotor is made from a solid forging, expansion of the rotor coils being provided by a sliding metal sleeve, fitted between the rotor end connections and the coil retaining rings. Generators are ventilated on the closed air system in both stations, but in contrast with the generators of Station A, ventilation for the latest generator is divided, 50,000 cubic feet of cooling air being supplied by self-contained fans on the rotor and 50,000 cubic feet per minute by two separately driven external fans.

Condensers.

The general particulars of the new condensing plant in engine-room B are given in the following schedule, contrasted with those relating to the condensers in engine-room A :—

Table IV.

	Station. A.	Station. B.
Rating, steam condensed, lb. per hour	240,000	265,000
Cooling surface, sq. ft.	40,600	32,000
Circulating water at 55 deg. Fah., galls. per hour	2,280,000	1,860,000
Vacuum, in. Hg. at 30in. bar.	29·1	29·0
Number of tubes	7,886	5,686
Material of tubes	Adm. mix.	Adm. mix.
Length between tube plates	19ft. 5in.	21ft. 6in.
Normal dry air quantity, lb. per hr.	230	200
Extraction pump power, B.H.P.	2 × 67	2 × 60
Manufacturer	Richardson Westgarth	Richardson Westgarth

Whereas in the earlier condensers the arc of steam admission over the tubes extended over about one-half of the periphery, in the new condenser the arc had been considerably increased. The effective depth of the condenser is thus reduced, tending to a more even distribution of steam over the tube surface and a correspondingly higher rate of heat transmission. The tube plate arrangements are shown contrasted in Fig. 4. The tube bank of the new condenser is divided by shielding diaphragms into wedge-shaped sections. While in the first condensers an air outlet was provided at each side, the last condenser has a single air outlet. This change permits an increase in the arc of steam admission towards the bottom at one side. It will be noted that a wide free lane extends through the new condenser from the top to the bottom. This passes a quantity of steam direct to the lower tubes, where it is probably condensed by direct contact with falling water rather than by contact with the cooling surface. The provision of a large air cooling chamber reduces the quantity of vapour carried over to the air ejectors and thereby increases their air withdrawing capacity. These changes in design, together with the reduction of 0·1in. in designed vacuum enabled the surface of the new condenser per pound of steam condensed to be reduced to three-quarters of that in engine-room A and reduced the under cooling of the condensate from approximately 7·6 deg. Fah. to 1·0 deg. Fah. In both cases the shell is built of riveted mild steel plates, welding being employed to secure the body flanges and pads for pipe connections. The shell of the later condenser is built up of one mild steel wrapper plate, ⅜in. thick. The water heads are of cast iron with core of mild steel plate. No special door handling gear is used, as the numerous manholes provide sufficient access to all tubes for cleaning, and it is therefore rarely necessary to break the door joints.

Each of the two three-stage steam-operated ejector units employed for the new condenser is capable of dealing with 60 per cent. of the maximum air quantity to be expected. Under ordinary operating conditions it is necessary to employ only one set and less than 1000 lb. of steam per hour maintains the specified vacuum. The oxygen content of the condensate at the bottom of the condenser is maintained at about 0·08 c.c. per litre. To avoid air leakage into the condensate the glands of the extraction pumps are pressure sealed, as are also the joints of the pump casing. The extraction pumps are in duplicate.

(*To be continued.*)

THE IRON AND STEEL INSTITUTE.

The Annual Meeting will be held at the Institution of Civil Engineers, Great George-street, Westminster, on Thursday and Friday, May 1st and 2nd, 1930, commencing each day at 10 a.m.

The following programme has been arranged :—On Thursday, at 10 a.m., a General Meeting of Members will be held to consider the Annual Report and Statement of Accounts for 1929. Presentation of Bessemer Gold Medals. Discussion on "An Experimental Inquiry into the Interactions of Gases and Ore in the Blast-furnace. Part II.: Carbon Deposition at 450 deg. Cent. and its Influence upon the Ore Reduction ; Equilibria between Gases and Ore at 650 deg. to 1000 deg. Cent.," by Messrs. W. A. Bone, L. Reeve and H. L. Saunders. "Developments in Fuel Economy at Skinningrove," by Mr. F. Bainbridge. At 2.30 p.m. a discussion will take place on "Single-sheet or Thin-pack Normalising, or Heat Treatment *versus* Box-annealing of Sheets," by Mr. R. Whitfield ; "Tin and Sheet Mill Rolls : Their Treatment, Performance and Premature Failure in Service," by Mr. E. Mort ; "The Metallography of Some Ancient Egyptian Implements," by Sir H. C. H. Carpenter, F.R.S., and Mr. J. M. Robertson ; "Chromium-Copper Structural Steels," by Mr. J. A. Jones. At 7.30 p.m. the annual dinner of the Institute in the Grand Hall, Connaught Rooms, Great Queen-street, W.C.

On Friday, at 10 a.m., discussions on "Some Alloys for Use at High Temperatures : Nickel-Chromium and Complex Iron-nickel-chromium Alloys ; " Part I., by Messrs. W. Rosenhain, F.R.S., and C. H. M. Jenkins ; Part II., by Messrs. C. H. M. Jenkins, H. J. Tapsell, C. R. Austin and W. P. Rees ; "Alloys of Iron Research : Part IX., The Constitution of the Alloys of Iron with Silicon," by Messrs. J. L. Haughton and M. L. Becker ; "Carburising and Graphitising Reactions between Iron-carbon Alloys, Carbon Monoxide and Carbon Dioxide," by Mr. M. L. Becker ; "The Effect of Melting Conditions on the Microstructure and Mechanical Strength of Grey Cast Irons containing Various Amounts of Carbon and Silicon," by Messrs. A. L. Norbury and E. Morgan ; "The Properties of some Steels Containing Chromium," by Messrs. A. R. Page and J. H. Partridge. The following papers will be presented at this meeting and discussed by correspondence :—"The History of the Cementation Process of Steel Manufacture" ; Part I., by Mr. D. Brownlie ; Part II., by Baron de Laveleye ; "The Corner Ghost in Steel Ingots," by Mr. S. Maita.

Railway and Road Matters.

SPEAKING at the annual meeting of the combined companies that form the London "Underground" Railways group, Lord Ashfield, the chairman, remarked that the delays on the railways were down to four minutes per 10,000 miles run. That was a record and was mainly due to the greater care and attention which had been paid to the rolling stock.

THE annual report of the Metropolitan District Railway Company shows that in 1929 it carried 1,780,948,937 passengers, of whom 65,607,932 were booked at workmen's fares, as compared with 1,744,771,986 passengers, including 62,465,869 workmen, in 1928. The average fare per passenger was, however, 1·91d., as against 1·93d. The gross receipts were £1,605,538, as compared with £1,550,328, and the net receipts £541,528, as against £541,802.

ANSWERING a question addressed to him on March 20th, as to a train running into a motor car near Burton-on-Trent, the Minister of Transport said that the accident appeared to have been due to lack of care on the part of the driver of the motor car. Proceeding, Mr. Morrison said that under the Railway Clauses Act, 1865, he already had the power to require railway companies to abolish level crossings, to which Sec. 7 of that Act applied, if necessary for the public service. He was prepared to consider applications from highway authorities for financial assistance towards well-considered schemes.

THE Ministry of Transport railway statistics for December have recently been issued as a Stationery Office publication, price 3s. 6d. They show that, compared with December, 1928, there was an increase of 1·9 per cent. in the number of passenger journeys made, but the receipts therefrom decreased by 1·2 per cent., combined with an increase of 1·9 per cent. in the passenger train mileage. Thanks to an increase of 8·1 per cent. in the tonnage of coal, coke, and patent fuel, the tonnage of the merchandise traffic rose by 5·6 per cent. The freight traffic receipts increased by 0·6 per cent., and the train mileage by 4·6 per cent. The average train load increased from 129¾ to 130¾ tons, and the net ton-miles per engine hour from 418¼ to 426¾.

THERE are four lines of way for the whole of the distance from Elland to Normanton on the former Lancashire and Yorkshire, except for the short length at the west end of Mirfield Station, where the railway crosses the river Calder. That length of line is now to be quadrupled under the Development (Loan Guarantees and Grants) Act. Another piece of work which, under the same Act, has been approved by the Government is the widening from two to four lines of the 1¾ miles between Broadholme signal-box, north of Belper, near Derby, and Ambergate. That work will necessitate the opening out of Alderwasley tunnel, which, as it was completed in 1840, is no doubt of reduced dimensions as to structure gauge when compared with the requirements of the present day.

OF the 93,858 steam-worked trains that ran on the Southern Railway in January last, 66·87 per cent. arrived at their destination on time, 26·63 per cent. were from 1 to 5 minutes late, and 5·26 per cent. were from 6 to 10 minutes late. The average late arrival was 1·32 minute. Whilst that is a very good record, the freight trains made a yet better showing, as of 16,957 trains run, 87·5 per cent. arrived on booked time and 8·7 per cent. were from 1 to 15 minutes late. Equally creditable was the fact that the average late start from the commencing point was only 1·9 minute. The *Southern Railway Magazine* for March, in giving the statistics from which the above facts have been extracted, says that fortunately there was very little fog during the month, but heavy gales caused a certain amount of dislocation and late running.

THE announcement that the London, Midland and Scottish Company is installing colour light automatic signals on "17 miles of double track" between Euston and Watford suggests that only the two lines that are equipped for electric traction will be automatically signalled. There are six lines of way between Euston and Bushey, of which two were provided, partly before and partly after the war, for the electrical services. They are joined at Chalk Farm by two electrically equipped lines from Broad-street and at Queen's Park by the Baker-street and Waterloo line of the London Electric Railways, and at Willesden by two other lines from Broad-street, *viâ* Hampstead Heath. At Bushey the electric lines turn to the west leaving the route of the main line to the North and go to Croxley Green and to Watford, *viâ* Watford, High-street, Station.

IT was forty years on March 28th since a collision on the North British Railway at Charing Cross, Glasgow, in which seven passengers were killed, made history in railway signalling. For over twenty years the Board of Trade inspectors had been recommending in their reports on railway accidents that the lock-and-block system should be provided as a means to prevent collisions. That system, like practically all safeguards, had a drawback; if a train were cancelled and by not going forward did not effect its own release, the signalman was locked up. Mr. W. R. Sykes met the complaints of the operating department as to the delays that would result by providing a releasing key. Directly that was done one of the merits of the arrangement was gone, as the signalmen could release themselves. That is what happened on March 28th, 1890. A train was delayed so long in a station, as a result of a defect in the Westinghouse brake, that the signalman, who could not see the train, felt sure that it had gone, and went to clear the line on his block instrument. That he could not do because, the train not having left, the lock-and-block held the instrument. He thought, however, that it had failed, and used his releasing key to accept a following train, with, as related, fatal results. Sir Arthur Yorke, in reporting on the accident, said: "I have no hesitation in saying that although the company has gone to the expense of supplying this most useful apparatus, which, if properly used, would render such an accident almost impossible, it has not received fair treatment or been employed in the manner prescribed by the rules." The W. R. Sykes Company thereupon designed a co-operative movement which required the man in the signal-box in advance to take part in the release.

Notes and Memoranda.

AMONG the hydro-electric installations of Canada there are eighteen with an output of over 100,000,000 kilowatt-hours per annum.

STEEL castings may be considered by some people as a comparatively modern innovation, but that the art is of some antiquity is vouched for by an illustration in the current issue of the *Edgar Allen News*. In it there are depicted anvils, gear wheels, hydraulic cylinders, and so forth, which were cast somewhere about 1873.

CELLULOSE films are, according to Dr. H. Levinstein, generally good insulators—a property which has recently opened up new fields of usefulness for all types. The thin film has been tried in electrical condenser work, and also instead of paper for cable insulation. The results are encouraging and further developments are expected.

THE recently issued Home Office report on the danger to employees in the asbestos industry caused by the inhalation of dust, emphasises, as preventive measures, "the education of the individual, as in other dangerous trades, to a sane appreciation of the risk, and to his personal responsibility in the prevention and suppression of dust." The protection afforded by respirators was, it is said, only partial, and there was a real danger that the use of them might give a sense of false security.

AN auxiliary, solid-drawn copper steam pipe on a steamer burst and the accident was inquired into by the Board of Trade. The Engineer-Surveyor-in-Chief explains that the pipe was about 23 years old and had been repaired on two occasions, the last being about 12 years ago. There had been no indication since that the pipe was in any way defective. The local thinning of the pipe was not of itself sufficient to cause the explosion, and it is not known whether the condition of the material of the pipe was due to its treatment during the repair or its age. It is advisable that any steam pipes, the failure of which may cause loss of life, should be annealed and tested periodically.

IN dealing with the cause and prevention of accidents, in a lecture before the Junior Institution of Engineers, Mr. S. Taylor gave the result of his own experience and the information obtainable from statistics obtained by inspectors and others under the Factory Acts. In 1928 over 154,000 accidents, including 953 fatalities, were reported from factories, docks, buildings, &c., in this country, and these had been classified according to the principal impersonal factors which caused them, and it would probably surprise an audience of engineers to learn that over 108,000, or over 70 per cent., of such accidents, and 524, or over 50 per cent., of the fatalities, were due to causes not connected in any way with the use of machinery.

A GOOD example of how an exhibit at the British Industries Fair may bring a firm business from sources quite outside its ordinary sphere of activity was to be found in the scientific and optical instrument section at Olympia. An old-established firm manufacturing lights for navigation purposes and lighthouse equipment, whose principal exhibit was a revolving light for a navigation buoy, had over a hundred inquiries for the use of this particular apparatus for advertising purposes, and the head of the firm announced his intention of starting a special department of his business to deal with the new and unexpected demand. These inquiries were in addition to excellent orders and inquiries from all over the world for the firm's products for their original purpose.

FOLLOWING tests made by officers of the Imperial Geophysical Survey Committee, the Tasmanian Mines Department has, says the *Iron and Coal Trades Review*, carried out development work in the Dundas district, and the results have borne out what the tests indicated. Four ore bodies of copper-nickel have been discovered, and, although this development at the present stage is important more from the scientific point of view, further work may lead to something of a commercial value. There were no indications of these ore bodies on the surface, but the survey indicated that they would be found, and they were at a shallow depth. The principal instruments used were those of the electro-magnetic type. Smaller ore bodies had been found in the district, but the Department was unaware of the existence of those discovered by the surveys.

WHEN the British Industries Fair of 1930 closed its doors at Olympia, London, and Castle Bromwich, Birmingham, it was, says the *Board of Trade Journal*, generally agreed among exhibitors and officials that it had been one of the most successful Fairs ever held. The depression in trade in the country generally did not affect attendances, which were the highest ever recorded. Business done was generally satisfactory, all sections of the Fair reporting more business than at the last Fair, and the number of new accounts opened and inquiries which are likely to lead to business in the future also compared very favourably with previous years. A criterion of the success of the Fair is that many of the 2000 exhibitors in London and Birmingham have already asked for space for 1931. Many of them want considerably increased space, and there have also been numerous applications from manufacturers who did not exhibit this year.

THE perils which may attach to temporary engineering works are emphasised by the following note culled from the *Engineering News-Record* of America: A disastrous fire last week in the falsework centering of the Boundary Creek channel spans of the Arlington Memorial Bridge again emphasises the potential danger from fires which exists on almost every construction job. Rarely is construction plant equipped with ample fire protection to offset the fire hazard. Forms, falsework and temporary works of all kinds are largely built of soft wood, and, in addition, the vast amount of trash and *débris* of all sorts which accumulates on every job constitutes a potential mass of fuel for a damaging fire. In winter construction the necessary use of open salamanders and canvas protection adds another element of risk. The hazard arising from all these conditions can be greatly reduced by providing adequate, but not necessarily elaborate, fire-fighting equipment, by keeping the work free of trash, and by establishing an efficient watchman service. The Arlington Bridge fire repeats a useful warning to contractors.

Miscellanea.

THE Ganges Canal hydro-electric scheme, which is nearing completion, has cost Rs. 74,40,000.

IT is estimated the proposed Pretoria works of the South Africa Iron and Steel Corporation will cost £3,500,000.

THE Ceylon Government is considering a scheme of hydro-electric supply, which will cost Rs. 1,45,00,000.

THE assembly plant of the Ford Motor Company at Norfolk, Virginia, is to be extended to produce an output of 120,000 cars a year.

THE pithead baths which have just been opened at the Parsonage pits, Leigh, of the Wigan Iron and Coal Company, Ltd., have cost £11,000.

A CHEMICAL factory with an annual output of 400,000 tons of superphosphate and 100,000 tons of sulphuric acid is to be put up at Leningrad.

THE Polish Government factory at Radom is to be equipped for the manufacture of bicycles. An annual output of 40,000 machines is expected.

IT is reported that the sodium sulphate deposits of the Ormiston district in Saskatchewan are to be exploited by a company which is to put down a plant costing some £100,000.

THE new pit of Amalgamated Anthracite Collieries, Ltd., at Cefn Coed, is approaching the coal-getting stage and will, it is claimed, be the largest anthracite colliery in the country.

IT is announced that the scheme for the erection of a blast-furnace plant near Teheran, Persia, will not be proceeded with until the construction of a railway across Persia has been completed.

THE Standard Oil Company, of California, has inaugurated a service for distributing liquefied natural gas, in steel bottles, for domestic purposes, in districts where gas is not supplied through mains.

A MINING centre for the higher education of colliery technical students is to be erected by the Durham County Council Education Authority at West Stanley. It is estimated that the building will cost £6400.

THE total quantity of plumbago exported from Ceylon during the year 1928, of which the latest official figures are available, was 14,346 tons 11 cwt., as compared with 12,884 tons 6 cwt. for the previous twelve months.

AN order for some 95,000 tons of coal for the Belgian State Railways has been secured by a Leeds firm of exporters. The coal is to be exported from Humber ports and will be delivered between April and September.

A BRIDGE is to be built over the river Irrawaddy about 9 miles from Mandalay to the designs of Messrs. Rendel, Palmer and Tritton. The steel work, which will amount to some 10,000 tons, will be supplied by Braithwaite and Co. (India), Ltd.

THE Belgian Minister of Transport has obtained his Government's approval of the plans for the Brigden–Neeryaren section of the Antwerp–Liége canal. The plans make provision for a junction between the existing canal and the new Antwerp–Liége canal.

WE are informed that the proposal to hold an Ironmongery Exhibition at the Agricultural Hall, London, N. 1, this year has now definitely been abandoned. The organisers, however, are considering the possibility of holding one in the early part of next year.

A COMPANY with a capital of £10,000 has been formed for the purpose of growing timber for box wood and wood-wool on a site of 4000 acres within 6 miles of Pretoria. It is proposed to concentrate on *pinus insignis*, which, it is expected, will produce timber in one-third of the time taken by the same species in Europe.

A BEQUEST of 50,000 dollars for an endowed laboratory of applied practical hydraulics, to be established at Harvard University, was provided for in the will of Clemens Herschel, eminent hydraulic engineer and Past-President of the American Society of Civil Engineers, whose death was noted in our issue of March 28th.

IT is noteworthy that the veteran oil engine, which we described as being exhibited in operation at the British Industries Fair, has now resumed its usual work. This engine, the first Hornsby made, was originally installed at Fenny Stratford thirty-eight years ago for pumping work, and was subsequently bought by Mr. W. Evans, of Bletchley, for timber sawing, and has been at work there ever since. During the Fair it had a comparative holiday, as it worked under light load, but even that is a trying condition for oil engines, and we were struck with the smoothness with which it ran.

THE principal islands of Greece are to be linked up with Athens and the mainland by wireless telephone and telegraph services, for which the Greek Government has ordered equipment from Marconi's Wireless Telegraph Company. Three of the latest type Marconi stations for duplex telephony and high-speed telegraphy are to be erected, one in or near Athens, with duplicate plant, one on the island of Crete, and the other on Chios. A similar Marconi station, but working on telegraphy only, is also to be installed to exchange messages with ships. The equipment of this station will include a Marconi wireless direction finder for the assistance of navigation.

THE *Edgar Allen News* is in a reminiscent vein in its issue for March and brings back visions of Mushet steel. It is noteworthy that Mushet steel is contemporary with Bessemer steel. It is recorded that "the first ingot of 'self-hardening' steel that could be successfully forged was made at Coleford, in the Forest of Dean, England, by the late R. F. Mushet, in the autumn of 1868. The new steel was evolved after several months of experimenting in steel alloying, conducted, by the way, with quite another object in view. Mr. Mushet wished to take out a patent, but I (Mr. R. Woodword) opposed that method of telling everybody 'how it was done,' and reminded him of the patents he had already taken out, and the absence of benefit therefrom to himself. I said, 'Let us try a secret for once,' and a secret it has remained for thirty-three years and is likely to remain."

ELECTRICALLY-OPERATED 100-TON TESTING MACHINE

W. AND T. AVERY, LTD., BIRMINGHAM, ENGINEERS

(*For description see page* 383).

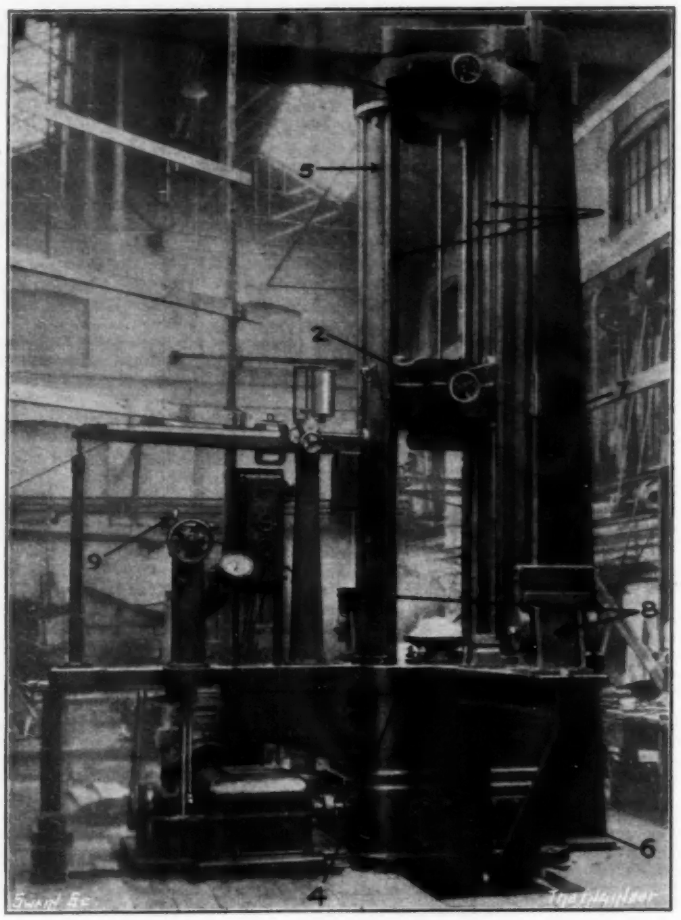


FIG. 1—GENERAL VIEW OF MACHINE

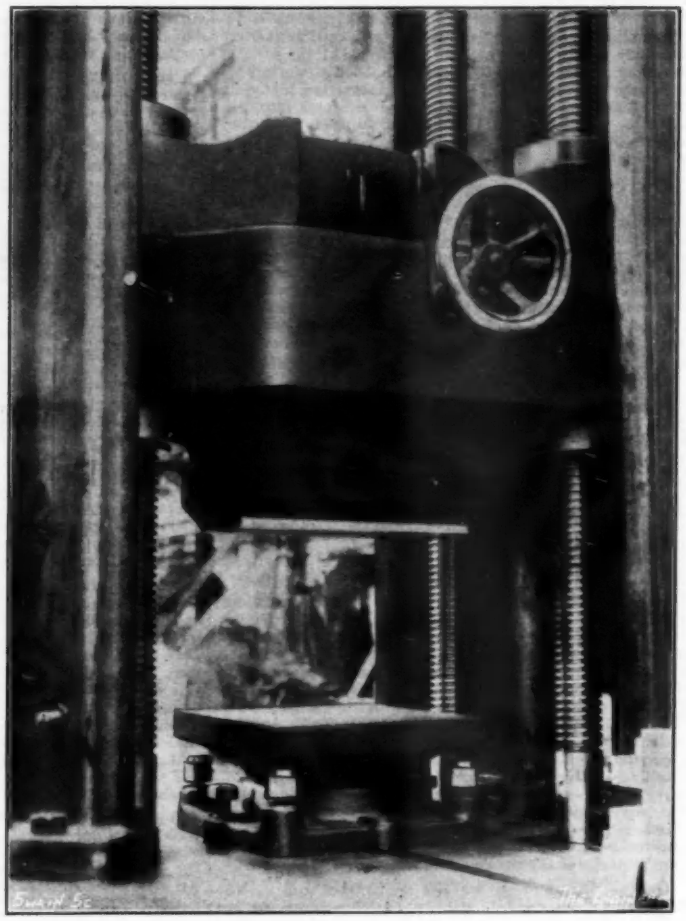


FIG. 2—COMPRESSION PLATEN AND TENSION HOLDER

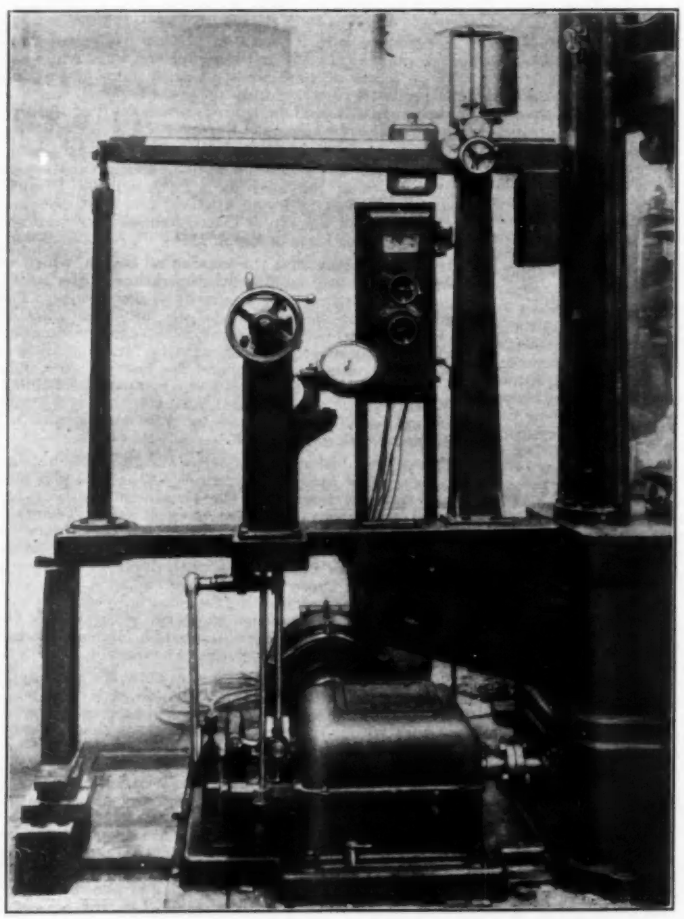


FIG. 3—STEELYARD AND GEAR-BOX

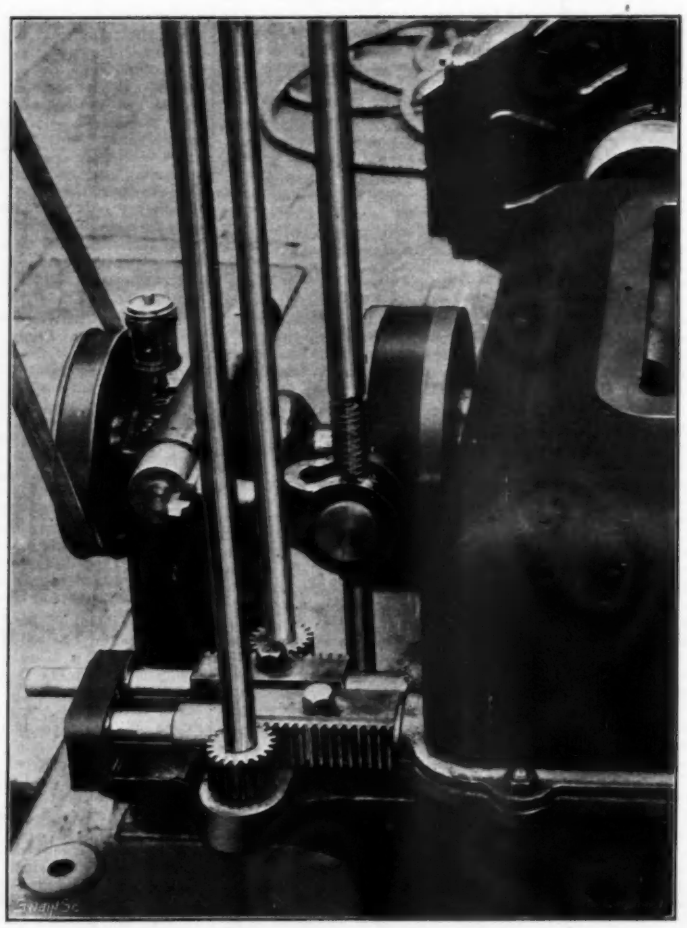


FIG. 4—FRICTION CLUTCH AND GEAR-BOX DRIVE

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THE ENGINEER.

VOL. CXLIX No. 3873

APRIL 4, 1930.

Earning and Spending on the Railways.

THE tables, given on another page, showing the results of last year's working on the four grouped railways, indicate that the railway situation in 1929 was not as bad as was generally thought. Whilst it is true that, when compared with 1928, the companies lost two million pounds on the passenger traffic, they gained over three millions on their freight traffic and over half-a-million from businesses other than railway operation proper. The London, Midland and Scottish was the worst hit in the passenger business, its loss therein being just one-half the total drop. All the companies contributed to the gain in freight traffic. Even the depression in the trades almost peculiar to some of the areas served by the London, Midland and Scottish, that led to the big drop in that company's passenger receipts, did not prevent an increase in the L.M.S. freight business by £400,000. The Great Western advanced under that heading by twice as much, but, with an increase of nearly two millions, the London and North-Eastern did best of all. In addition to the gain of nearly two millions in the total receipts, the grouped companies effected a saving of one million in the expenditure. It will, therefore, be seen that, compared with 1928, the companies were three millions to the good.

When railwaymen foregathered in that social spirit which, we fear, is less prevalent in these days of greater stress and more responsibility than it used to be, a matter for banter by the traffic people was that they earned the money while the engineering side spent it. That remark is still quite true, but the conditions are altered. Now that economies are so very essential, it is the engineering and not the traffic departments that are effecting the necessary savings. This fact is at once made evident by last year's figures. It will be seen from our tables that one million pounds were saved in the traffic expenses of railway working. It must, however, be remembered that those expenses benefited by the deduction of 2½ per cent. in salaries and wages over the whole year as compared with a similar deduction for only the last five months of 1928. The London, Midland and Scottish report stated that the resultant saving from the deductions to that company was just over a million pounds in 1929. Mr. Whitelaw told the London and North-Eastern proprietors that they saved £820,000 thereby. It may, therefore, be assumed that for the four companies the saving last year totalled over three millions. Hence, comparing twelve months' saving in 1929 with five months' benefit in 1928 we deduce that the traffic expenses were reduced by nearly two millions from that source alone. Comparing the results of 1929 with those of 1924—the second year of the grouping—we find that although the passenger receipts were nearly nine millions less in 1929, seventeen million more passenger train-miles were run, and that while locomotive running expenses—a traffic responsibility—fell by over five millions, practically four millions of that amount was represented by saving in fuel and only £700,000 by saving in enginemen's wages. One of the avowed objects of the grouping scheme was to lower the cost of working, and one means toward that end was the reduction of competitive services, thereby effecting economies in train mileage and operating staff. Not only, however, was the passenger mileage in 1929 7 per cent. greater than in 1924, despite a loss of 10 per cent. in the passenger receipts, but the freight trains ran 400,000 more miles to earn an increased £200,000. We know, of course, that to compete with road transport and its cheaper fares, the railways have had to offer increased facilities in order to retain some of their traffic. Certain of these increased facilities have involved the running of steam rail-cars and their mileage counts just as much as that of a main line train. It has been a troublesome problem, and we readily accord to the traffic departments credit for having done their best. It must, however, be remembered that, in distinct contrast with the results on the traffic side, the engineering departments have saved large sums of money. On the maintenance and renewal of "way and works," 8 per cent. less was spent in 1929 than in 1924 and 4 per cent. less on the maintenance and renewal of locomotives, carriages and wagons.

In 1929 the total expenses of the traffic departments were three millions less than in 1924. That figure also represents approximately the amount of the combined saving in the civil and mechanical engineering branches. The result seems very praiseworthy, but the case is weakened when it is noted that in salaries and wages there was a drop of £3,600,000, and, therefore, an increase of over half a million in other traffic expenses. That result has to be recorded despite grouping—and all the economies it was to bring—bad trade, &c. Moreover, included in the savings on wages there was the benefit of the 2½ per cent. deductions. These deductions were not operative in 1924 and over a full year represent, as said above, about three millions, which, it will be seen, happens to be the amount by which the traffic expenses in 1929 were less than those of 1924. In effect, therefore, outside the wage deductions the traffic department saved nothing last year in comparison with 1924. It is, therefore, clear that although the engineering departments may be the "spenders" and the traffic departments the "earners," the latter have yet to learn how to do their work at less cost. Ground for these observations is afforded by the tables on another page, wherein it can be seen that a million was saved in traffic expenses, and yet the 2½ per cent. deduction brought in a credit of about two millions.

High Power Mercury Arc Rectifiers.

THE paper on High-power Mercury Arc Rectifiers recently read by Mr. J. C. Read before the Rugby Engineering Society, and reprinted in its essentials in last week's issue, is a contribution to electrical literature of somewhat exceptional interest. Apart from the fact that it advances views that are somewhat opposed to those that have been previously expressed, it deals with an important and timely subject. Long ago we directed attention to the rapidly increasing use of rectifiers abroad with a view to urging British electrical manufacturers to cater for the business, and it is gratifying to find that two firms have at last made a move in that direction. Although Mr. Read's paper is not by any means the first of its kind to be read in this country, it is, we believe, the first to be written by an engineer connected with an English electrical manufacturing company. From the abstract published in our last issue it will be perceived that the author cannot be accused of over-rating the merits of the rectifier; in fact, for ordinary power and lighting service at a pressure of 500 volts or less he

seems inclined to condemn it. Never, so far as we can remember, has any other writer on the subject arrived at precisely the same conclusions as Mr. Read, who obviously has no desire unduly to injure the rotary converter business. The object of the paper is clearly to advocate the use of rectifiers for high pressures and to persuade engineers to adhere to machines for lower pressures such as those adopted for general purposes. The scope for rectifier manufacturers at the moment would therefore appear to be rather limited. But whilst it is true that rectifiers give the best performance at the higher voltages, up to the present Brown, Boveri and Co., the originators of the high-power metal-cased apparatus, have supplied more plant for 500 volts and less than for pressures between 500 volts and 1000 volts and above. For use on circuits working within these three ranges of pressure—*i.e.*, 500 volts and less, between 500 volts and 1000 volts, and from 1000 volts upwards—the capacities of the apparatus installed to date are 422,000, 378,000, and 200,000 kilowatts respectively. Thus, although, according to Mr. Read, 500-volt rotary converters show advantages as regards efficiency, cost, and floor space, the progress of the rectifier has been more pronounced at that pressure than at any other.

The fact that the apparatus resembles a transformer is important. Static apparatus can be installed in places where machines would not be permissible, because of noise and vibration, but we do not believe that this fact alone has been responsible for anything like all the orders that have been secured. Certain engineers have favoured the rectifier, because rightly or wrongly, they have concluded that because it has no large and heavy moving parts, it is exceptionally easy to operate and cheap to maintain. The location of the sub-station building, the possibility of a change of frequency, and the existence of a very low load factor are items which have no doubt sometimes turned the scale in favour of the rectifier, but the mere fact that it is practically a static piece of apparatus appeals strongly to some electrical engineers. When it is remembered that on the Berlin suburban railways there are no fewer than 119 800-volt rectifiers, it becomes evident that the opinion that the apparatus is mainly suitable for working pressures of 1500 volts and upwards is not universally accepted. Automatic control favours the rectifier, but, according to Mr. Read, only to a limited extent. Others maintain, however, that the advantages in this connection are considerable, and that much of the complication associated with automatic converter sub-stations is eliminated by the use of rectifiers. Although the practice of starting rotary converters on the tap-changing principle has been simplified by the provision of roller bearings, which avoid the necessity for brush-lifting gear, it appears from a casual consideration of the matter that it still ought to be possible to make an automatic rectifier sub-station less complicated than one containing machines. The fact that some engineers declare one type of automatic plant to be simpler than the other, while some maintain that there is little to choose between the two, is, to say the least, unsatisfactory. The point can only be settled by a study of the wiring and the devices associated with the two schemes, but we do not remember having seen a paper containing comparative diagrams or details that would enable a definite conclusion to be formed. On the question of the cost of maintaining the two types of plant there also seems to be diversity of opinion, for while Mr. Read is not inclined to give the rectifier much preference on this score, others maintain that the cost, in the case of automatic operation at any rate, is exceptionally low.

One point on which practically all electrical engineers agree is that the rectifier is highly suitable for the supply of high-pressure direct current, and particularly for feeding 3000-volt railways. Compared with the motor generator commonly employed for this service, it offers advantages which no one can ignore. Generally speaking, it is, in our opinion, also preferable to two 750-volt, series-connected rotary converters for the supply of current to a 1500-volt traction system. But judging from the recent decision to work the Brighton line at 600 volts, there is not much prospect of a demand arising for 3000-volt rectifiers in this country, where there is a tendency to avoid the use of high pressures, or, at any rate, not to exceed 1500 volts. The prospect of the 3000-volt system coming into service seems to be rather remote, and if Mr. Read is correct in assuming that the main application of the rectifier is to be found in this field, the home market is likely to prove disappointing. The fact that low-pressure rectifiers are being made in considerable numbers abroad indicates, however, that the plant is not universally considered unsuitable for those pressures. Early experiences in this country were perhaps not very encouraging. The troubles have, however, been overcome, and now that British firms are manufacturing rectifiers there is every reason to suppose that the business will develop here on the same lines as it has followed abroad. While there are conditions under which rectifiers cannot be employed, records do not by any means indicate that the two types of plant are, generally speaking, only competitive when the direct-current pressure is high.

The Institute of Metals.

No. IV. (*conclusion*).*

The first paper in the afternoon of Thursday, March 13th, was by Messrs. L. Davies and L. Wright on "The Protective Value of Some Electro-Deposited Coatings." The authors were unable to be present and the paper was taken as read and discussed in their absence.

ELECTRO-DEPOSITED COATINGS.

The work outlined represents investigations carried out during the year 1929 on a large number of specimens of steel, brass, phosphor-bronze and copper. The specimens were plated with cadmium, zinc, nickel and chromium of thicknesses 0·0001in., 0·0005in., 0·001in., and 0·002in., and were subsequently exposed to accelerated corrosion tests. The paper is concerned with the production of deposits of a thickness frequently specified or recommended, and with their comparative behaviour to corrosion sprays of salt and sulphuric acid.

Under the conditions outlined, cadmium afforded better protection than zinc against the sulphuric acid spray. Against the salt spray the thinnest deposits of zinc gave better protection than the corresponding cadmium deposits. In general, for equal thicknesses of zinc and cadmium, the intrinsic protection afforded by the zinc more than compensates for its higher solution potential. Chromium deposits afforded no protection whatever to steel, but very good protection was afforded to the non-ferrous basis metals. A deposit of 0·002in. nickel was found necessary to give any degree of permanent protection to steel.

For general purposes nickel deposits appear to be most suitable, but no deposit can be recommended unless the service conditions are known.

Mr. Ulick R. Evans suggested that if the salt spray or acid spray test could be improved, better results could be obtained even than those mentioned by the authors, whose tests, for the first time, had been conducted upon specimens plated under defined and controlled conditions. The method of testing had also been described in detail, and thus the results had a definite meaning which many earlier series of tests conducted on material plated under undefined conditions did not possess. Referring to the shortcomings of the spray test at present employed in most technical laboratories, Mr. Evans said that articles exposed to the atmosphere, even close to the sea, were not equally wet all the time. At times they were definitely wet, but at others they were able to dry up provided there was no hygroscopic body present. If the corrosion product, however, was hygroscopic, the articles remained wet even during the dry periods and corrosion of the "wet" type proceeded rapidly. Thus it was that metals which produced a hygroscopic compound with the chief anion present in the atmosphere were the metals which suffered the most rapid atmospheric attack. The hygroscopic character of the product was probably the most important factor in determining whether attack was rapid or slow under service conditions, yet in the salt spray test that factor was entirely without effect. The tests described by the authors suggested that the mere process of drying up had an important influence on the subsequent behaviour of the metal and that where the metal was kept wet all the time that influence was absent. That statement did not simply rest on laboratory work, for the difference had been observed in service. Galvanised iron sheets stacked on one another near the sea or in the hold of a ship, so that large drops or patches of salt water could remain for considerable periods between the sheets, had been found to suffer rapid rusting, but exactly similar sheets used for buildings near the coast, and alternately damp and dry, had been found to give fairly satisfactory service. The present form of salt spray test was advocated as representing "the conditions prevailing at the sea-side," but if the details of the mechanism of corrosion were studied it would be seen that the conditions in the spray box differed from those "prevailing at the sea-side," in certain vital particulars, and he expressed the hope that the authors would turn their attention to the scientific improvement of the salt spray or acid spray test.

Dr. K. L. Meissner pointed out that in the paper nickel and chromium were stated to be electro-negative to iron, whilst cadmium and zinc were said to be electro-positive. Sometimes, however, the opposite was found to be the case and yet both might be right from different points of view. In view of the danger of people being misled in that matter, he suggested the desirability of some standard terminology.

Mr. D. J. MacNaughton said that there was a standard terminology among electrochemists, and he was surprised that the authors had not made use of it in the paper. They had tested four metals, two of which were electro-positive to iron, viz., nickel and chromium, and the results obtained with sulphuric acid gave practically the same classification as obtained with the salt spray test; but to carry out either that test or the test suggested by Mr. Evans was rather tedious, and he felt that so far as metals that were electro-positive to iron were concerned a simple porosity test was the best. The ferro-cyanide test was well known, and it was possible to get a record of the distribution of the pores in a few minutes. As regarded zinc and cadmium, there was a good deal of controversy as to which was the better, but apart from the argument that cadmium was more expensive to deposit than zinc, the results seemed to show that cadmium was better than zinc under the sulphuric acid test, and that zinc was better than cadmium under the salt spray test. That rather suggested that in industrial areas cadmium should be used in preference to zinc, but that was a conclusion which ought not to be drawn from the paper, because the salt spray test did not simulate atmospheric conditions. The investigators in the present case had left out of consideration altogether the question of porosity of zinc and cadmium coatings, to which, he contended, attention must be given.

Mr. T. H. Turner supported the argument in favour of a porosity test, and added that he had also carried out tests with the spectroscope to determine corrosion. Where specimens were allowed to lie about for varying periods between the completion of the plating and the commencement of the corrosion test, very different results were likely to be obtained through the film of oxide formed on the metal, and the spectroscope method gave more reliable results in such circumstances than the salt spray method.

Dr. W. H. J. Vernon did not agree that the porosity test of itself could take the place of the salt spray test. Porosity, although an important factor, was only one factor, and to rely on the porosity test alone was likely to give misleading results. He felt that the authors were justified in using some sort of sulphuric acid test, because in their tests the conditions were largely inimical to the formation of protective films, the whole tendency being for the metal to be coated with a film of liquid. There was great difficulty in devising an accelerated test, but it was highly desirable that the attempt should be made to find a series of accelerated tests, and he welcomed the work of the authors as a step in that direction.

Prof. F. C. Thompson said the authors had come to the conclusion that chromium deposits were no use for the protection of steel. That might represent the case under the conditions of the authors' tests, but it was not invariably the case. It appeared that the authors did not use a preliminary coating of copper or nickel, which was commonly done in practical work, and it should be placed on record that the results which they had obtained in that connection only applied in the case of the deposits they used and that the conclusions were not generally applicable.

Mr. W. B. Clarke suggested that nearly all corrosion tests were being handled from the wrong end. For example, it was stated in the paper that after all grease had been removed and the specimens had been washed free from alkali, &c., they were washed in running water and then transferred to the plating bath. He wondered if anybody had taken the trouble to measure the acidity of the running water used for washing the articles before they were placed in the plating bath. There had been a considerable amount of trouble with nickel plating at various times, and it would probably be rather surprising to some to find the amount of acid left on the articles after they had been through the so-called running water. If a delicate test were applied it would be found that a considerable amount of acid was left on the articles. A case in point was presented by composite wires for leading-in wires for electric lamps. There was a nickel-steel core which was silver-plated and afterwards coated with copper, and the trouble was traced definitely to the fact that unless the articles were washed in running water for 24, or even 48, hours completely to remove all traces of acid from the deposited coating, there would not be a satisfactory result in the subsequent corrosion test. It was better to use distilled water to see that there was no acid on the protective coating before applying the salt spray test.

Mr. Ulick Evans made a few remarks in winding up the discussion in the absence of the authors.

The following paper was then presented:—"A Note on Zinc-base Die-casting Alloys," by R. Lancaster and J. G. Berry.

ZINC-BASE DIE-CASTING ALLOYS.

The effect of adding small quantities of magnesium to a zinc-base alloy, hardened with copper and aluminium, has been examined. There is a variation in the physical properties, and a distinct change in the crystalline structure, with successive small additions of magnesium.

Mr. John Cartland said the paper formed a link between the academical and the practical side of industry. The origin of the paper was a complaint: a certain delivery of die casting alloy was not equal to somebody else's brand, and in investigating that complaint facts were discovered which seemed to be of sufficient interest to submit to the Institute.

Professor T. Turner said he was interested to learn that the addition of small quantities of magnesium produced so marked an effect, and that the addition of a further small quantity caused the sample

* No. III. appeared March 28th.

apparently to revert to its original structure and to have even less satisfactory mechanical properties than it had at first. Apparently the addition of the first small quantity of magnesium produced much greater uniformity in the strength of the material, and corresponding with that there was both a higher tensile strength and less red shortness.

Dr. W. Rosenhain remarked that the explanation asked for by the authors could only be given after very much further research. Certainly no adequate explanation could be offered, taking the facts as set out in the paper. As Chairman of the Die Castings Committee of the Department of Scientific and Industrial Research, it was interesting to him to compare the results obtained by the authors with those obtained by a Committee whose final report, he hoped, would shortly be published. Some of the results had already been published, and he was a little chary of the kind of results the present authors had put forward. What they had really done was to take a chill cast test bar and make an ordinary tensile test piece out of it, and he did not regard that as being typical of a die casting at all. He did not think the figures in the paper were comparable with those which could be obtained with an actual die casting made to shape. Again, were the authors certain that the alloys they had produced were permanently stable? There was a good deal of doubt as to the permanent stability of zinc-base alloys hardened with aluminium and copper. He found that they were not stable when they were investigated some years ago, although he knew that that view had not been accepted by everybody and more favourable experiences had been obtained. Nevertheless, he would like to be quite certain that the authors were sure of their ground in that respect.

Mr. Lancaster, replying on the question of the stability of the alloy with magnesium added, said the work described in the paper was only completed a fortnight before the paper was due to be sent in, and although there were a number of test bars undergoing an ageing test, it would be some time before actual figures relating to the stability could be put forward. He agreed with Dr. Rosenhain that a chill casting was the ideal to be aimed at, but the figures in the four cases mentioned in the paper were comparable.

Professor Bernard P. Haigh and Mr. B. Jones then presented a paper entitled "Atmospheric Action in Relation to Fatigue in Lead."

ATMOSPHERIC ACTION AND FATIGUE IN LEAD.

The paper gives a detailed account of a number of fatigue tests carried out under abnormal conditions that were specially devised to study the action of air in relation to fatigue in lead, it being believed that this action is representative of conjoint chemical and mechanical action.

It is shown that an oil bath round the test piece, or even a water bath, greatly delays fatigue in lead, and that a thin layer of grease delays fatigue appreciably. A bath of acetic acid appears to eliminate fatigue in lead, although a thin film of the same acid does not do so.

It is shown that the fatigue fracture of lead is intercrystalline only round the margin, and that, in general, the interior surface of a fatigue fracture differs in character from the marginal zone.

The experiments are regarded as showing that oxygen diffuses through lead subject to cyclic stress, and that, at an appreciable depth below the surface, it provokes a conjoint chemical and mechanical action that leads to fatigue cracking.

Dr. H. J. Gough commented upon the importance of the suggestion made by the authors that fatigue cracking commenced within the specimen. One reason for that was stated to be the marginal zone and the different colour of the inner material. In the case of lead he had no experience, but he had examined freshly broken specimens of steel, copper and duralumin, and whilst in a few cases the marginal zone was apparent to some extent, in the large majority it was entirely absent and no inner zone was evident. The authors also stated that in the case of lead the crack did not appear on the surface until the specimen had failed, but if that were the case with lead it was certainly not so with regard to iron, steel, copper, aluminium, zinc and antimony, because he and his colleagues had watched surface cracks appear in those metals and spread for many millions of reversals before total fracture occurred. With regard to the comparative tests made in air and surrounded by oil, he had carefully plotted the authors' data to logarithmic scale. The tests made in air were not sufficient to disclose a real fatigue limit, and he agreed that the oil bath did not necessarily raise the fatigue limit. There was little doubt, however, that total immersion in normal acetic acid had increased the fatigue limit, even though the surface of the test piece was deeply corroded, and that appeared to be a most important observation. Could it be that lead had two fatigue strengths? Was it possible that the lower value was revealed normally when the conditions were such that the fatigue crack was initiated and propagated itself along the boundaries, but that if by any chance that action was suppressed then a higher stress value was required to produce the transcrystalline type of failure? Perhaps by some mechanism not yet understood the intercrystalline type had been suppressed and the higher strength developed. That could easily be tested by finding the fatigue value when immersed and examining the type of fracture, and he hoped the authors would experiment on those lines.

Mr. H. C. Lancaster spoke of the value of the paper to the lead industry. If the statements in it could be accepted as facts, then many of the troubles of the industry would fade away. Some of the statements put forward, however, were difficult to believe. For instance, it was stated that the air passed through both sides and that the oxygen was extracted in the centre. That might be right, but it seemed incredible. For practical purposes, lead was the one thing that would prevent the emanations of radium, and it passed his comprehension that air would pass through the skin and that there was something in the inside which was so selective that it would take up the oxygen. It might be so, but he could not follow it. For oxidation in the centre, he contended that there must be a very high temperature there, and he did not believe it was possible to have oxidation unless there was such a temperature that the bar would break down through melting.

Dr. W. H. J. Vernon, referring to the chemical factor influencing the type of failure under consideration in the paper, suggested that, contrary to what was stated, it was necessary for oxygen to have access to the surface if failure was to occur, and that anything interfering with the access of oxygen hindered or prevented fatigue failure.

Mr. T. S. Robertson said he had seen many of the tests carried out at Woolwich, and the feature of the fractures was the thin outside crust, about $^1/_{32}$in., whilst the heaviest oxidation took place just inside that crust. Then it decreased and the appearance of the crust was certainly crystalline. It appeared to be an intercrystalline fracture which took place outside the crust.

Professor F. C. Thompson remarked that in 1924 Millington and himself published the theory that elastic failure and fatigue failure always took place at a free surface. He did not think many people accepted that at the time nor even now, but all the same he believed it was true. It was stated by the authors that lead was not permanently hardened when it was deformed, and that was true; but it was equally true that temporarily lead was hardened very much indeed. That was true when elastic deformation or fatigue took place at the surface, and he could see in that a complete explanation of the phenomena the authors had obtained in connection with the acetic acid test.

Dr. W. Rosenhain, F.R.S., said he disagreed with nearly every conclusion in the paper, and was inclined to doubt the correctness of the facts as set out. The idea of the authors was that lead was not hardened by cold work, but the answer, as proved by work done by himself some years ago, was that lead was hardened by cold work. He urged the authors strongly to make certain first of all whether the fracture was transcrystalline or inter-crystalline. There seemed to him insufficient caution in assuming that because the texture inside was different, it was because the mechanism of the fracture was different.

Professor D. Hanson confirmed what Dr. Rosenhain had said about the effect of cold working, and, with him, suggested a closer investigation of the problem before drawing final conclusions.

Professor Haigh, replying, said the lesson of the discussion was that they would have to go on and see what was really happening inside the metal. He hoped the point whether the fracture was transcrystalline or inter-crystalline would be settled. What did seem to stand out from the work that had been done, was that the air did play some part in the inside.

The final paper, that by Mr. W. R. D. Jones, on "A Note on Metallic Magnesium," was taken as read. There was no discussion upon it, and the proceedings closed with the usual vote of thanks to the Institution of Mechanical Engineers for the loan of its rooms for the meeting.

SIXTY YEARS AGO.

THE passage of time and the changes of outlook which have accompanied it are forcibly impressed upon us by a perusal of the proceedings at the 1870 meeting of the Institution of Naval Architects, as reported in our issue of April 8th of that year. Sir John Pakington was the President. In his address to the members he dwelt with much gravity on the safety of life at sea, and the unsatisfactory provisions made to ensure it. In the first ten weeks of the year, nine steamships had been lost, for the most part apparently by foundering, for nothing more had been heard of them. In four months during the previous year twenty-eight steamships had been lost at sea. Some of the casualties had arisen as the result of collision, two of the worst as regarded loss of life being that between the United States corvette "Oneida" and the P. and O. liner "Bombay," and that between the Channel Islands packet "Normandy" and the "Mary." The "rules of the road" at sea and in general regulations for the navigation of ships were, according to Sir John, in need of overhauling, and should be enforced by Government order with increased rigidity on captains. Of the ships which disappeared without leaving a trace of their fate, the most impressive recent instance was that of the Inman liner "City of Boston," of which no news had been heard after she had left Halifax, N.S. It was alleged that when she sailed from that port she was 18in. to 20in. below her proper draught. The allegation was denied, but Sir John dwelt upon the necessity for enforcing the provision of watertight bulkheads in ships and for securing obedience to rules for safe loading. The Institution had already been active in the matter of safety of life at sea. It had appointed a powerful and able committee of its members to discuss the subject. The Committee had duly reported, and its report had been sent to the Board of Trade. That Department, however, was quite out of touch, and apparently out of sympathy with the movement for increased safety. It replied that it did not think it desirable to carry out the recommendations made in the report. Following the President's address, Mr. J. D. Samuda read a paper on the influence of the newly opened Suez Canal on ocean navigation. He anticipated that the Canal would soon result in steamships monopolising the Indian trade, but that on the China trade sailing vessels would for some time to come continue to be used preponderatingly. Without considerable improvements in steamships, he had difficulty in foreseeing the time when sailing ships would be seriously challenged on the Australian route. Admiral Belcher then read a paper on the channel passage and international communication by railway steamships. He described a proposed train ferry which he suggested should be propelled by a turbine, a form of engine which, he said, would make the vessel peculiarly fitted to turn in a seaway. Mr. J. Scott Russell followed with a paper on "The Fleet of the Future." It is remarkable to-day for the author's complete failure to forecast the typical ship of the future, as it actually developed. He drew a picture of a naval engagement in which the chief and substantially the sole method of attack was ramming with the stem. If the ramming attack failed at the first attempt a broadside was to be discharged into the enemy before retreating, turning round and repeating the ramming attack. There were those present at the meeting who scoffed at Mr. Scott Russell's ideas, and emphasised the foolishness of attempting to anticipate future developments in warship construction.

100-Ton Testing Machine.

THE illustrations which we reproduce on page 380 represent a new form of 100-ton electrically operated testing machine, which has been supplied by W. and T. Avery, Ltd., of Birmingham, to the City of Leicester Colleges of Art and Technology. While it does not depart from the principle of testing by weight, it is of interest inasmuch as the design is exceptionally compact for a machine of such large capacity. As will be observed from the illustrations, it is of the compound lever type and is capable of carrying out tests in tension, compression and bending up to the full load. Specimens up to a maximum stretched length of 10ft. can be accommodated when tension tests are required, and wedge grips are provided to hold specimens up to 3in. in diameter.

The wedges are fitted to the weighing crosshead (1)—see Fig. 1—and to the straining crosshead (2) respectively. Each set is directly controlled by a hand wheel at the front of the machine, operating a machine-cut pinion and a rack. The two wedges in each holder are also interlocked so that they move together, and the crosshead can be adjusted on the three straining screws (3) so that various lengths of specimens can be accommodated.

When a test in compression is desired, the specimen is placed between the straining crosshead (2), and the surface of the weighing platform (4). In this test also a maximum length of 10ft. can be accommodated. The bearing platen for compression will take up to 12in. square and rests upon the surface of the weighing platform. It consists of a bearing block with a spherical seat to carry the platen block, which has a spherical under-surface, generated from the centre point of the compression face. The platen block, which is square, is provided with set screws at the corners to hold it in position when the specimen is being set. Diagonal lines and rings are engraved in the face of the block to facilitate the accurate placing of the specimen. In the bending test, specimens from 4ft. to 14ft. can be accommodated, with a maximum width of 16in. A scale is provided for indicating the span of the bending dogs.

On reference to the illustration—Fig. 1—it will be seen that there are three long columns (5) and extension brackets (6), all of which are connected directly to the weighing table. The separate column (7) which supports the straining screws and guides the straining crosshead is solidly bolted to the base. Hence, when a tensile test is being made, a downward pressure equal to the pull on the specimen is exerted upon the three columns. This load depresses the weighing table and, through a series of weighing levers, operates the steelyard. Similarly, when a compression test is being made the pressure is exerted directly on to the weighing table, and is transferred in the same way to the steelyard.

In the bending test, when the pressure foot attached to the straining crosshead is brought down upon the specimen, the pressure is transmitted to the bending dogs (8) fixed on the extension brackets (6), and is thence transferred to the weighing table in the same manner.

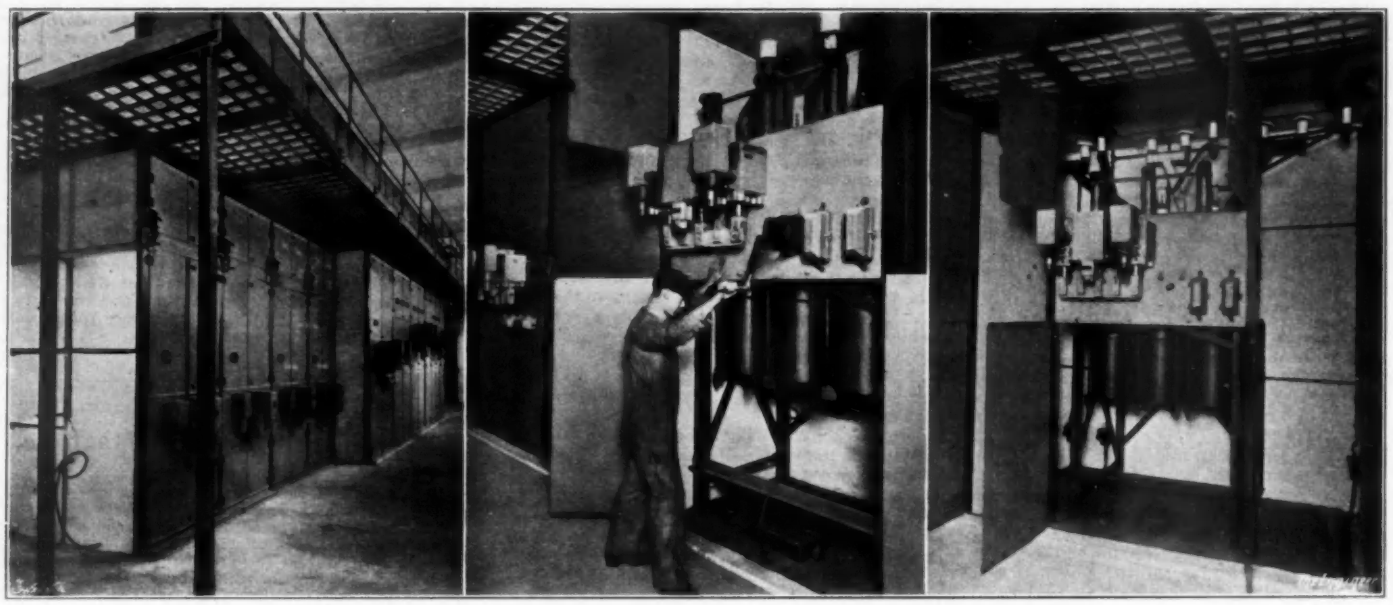
The engraving—Fig. 2—gives some idea of the compact design of the straining mechanism. Phosphor bronze nuts are fixed in the straining crosshead, through which are threaded the straining screws which pass through clearance holes in the weighing table to the straining gears in the lower section of the base box. A spur wheel is fixed to the lower end of each of the screws, whilst a central idle wheel connects the three spur wheels and all are driven by a main worm reduction gear. The worm shaft in its turn is coupled to a gear-box driven by a variable speed electric motor. A friction clutch—see Fig. 4—operated from the handle (9)—Fig. 1—takes up the drive, so that the motor need not be stopped whilst adjustments, &c., are being made. The electrical motor is of a reversible variable speed type, and by using the speed variations, in conjunction with the gear changes, the following crosshead speeds can be obtained:—0·1in. to 0·4in., 0·4in. to 1·6in. per minute, whilst for setting, 2in. to 8in. per minute can be realised.

The third illustration gives a view of the steelyard, and shows its compact proportions. The scale itself is machine-engraved from zero to the full capacity of the machine—100 tons by divisions of 1 ton—whilst a micrometer screw dial subdivides these readings into $^1/_{100}$th ton divisions. The poise is machined to suit the steelyard and is traversed by a machined cut screw which simultaneously rotates the micrometer dial.

Mounted on top of the steelyard column is an autographic recorder, the drum of which is caused to rotate by the movement of the straining crosshead, whilst the pencil carriage derives its vertical movement from the poise propelling gear.

SWITCHGEAR AT DERBY CORPORATION POWER STATION

THE BRITISH THOMSON-HOUSTON COMPANY, LTD., RUGBY, ENGINEERS



FIGS. 1 TO 3—SWITCH CUBICLES AND SOLENOID-OPERATED CIRCUIT BREAKERS

New Switchgear for the Derby Corporation Power Station.

THREE extensions to the original switchgear in the Full-street power station of the Derby Corporation have been necessary as the result of the continually increasing load, and the latest gear which, like all the other gear was made by the British Thomson-Houston Company, Ltd., has recently been put into service. The increase in size of the later turbo-generators has necessitated an increase in the rupturing capacity of all the oil circuit breakers. All the switchgear is of the back-to-back bus-bar type, and is accommodated in cellular type stone cubicles, each containing one circuit equipment, so arranged that by means of horizontal shelves and vertical barriers the risk of an arc spreading from one cell to another is reduced to a minimum. Each cell is fitted with a hinged stone door, provided with a padlock and interlocked where necessary to ensure access with safety. The connections passing from one cell to another are taken through close-fitting porcelain insulators, cemented in the stone structure. All the oil circuit breakers are solenoid-operated by means of small barrel type control switches, mounted together with red and green indicating lamps on the corresponding black enamelled slate panel of the control board—shown in Fig. 5. This flat panel board is in the turbine room, and is mounted on a gallery above the original bank of switchgear cubicles.

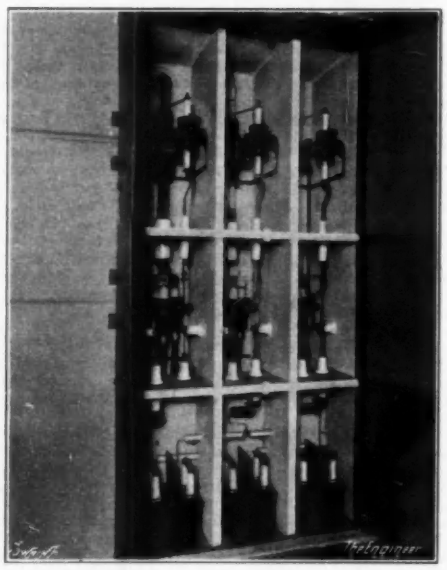


FIG. 4—INSTRUMENT TRANSFORMERS

All the isolators are mechanically operated and interlocked with their respective cell doors. The generators and transformers are fully protected by the B.T.H. system of circulating current protection, combined with standby definite time limit overload and leakage relays. Overload and earth protection is provided for the feeders. The neutral points of the generators are earthed through earthing resistances by means of hand-operated oil circuit breakers. The original bank of switchgear controls the first two 2000-kilowatt generators, eleven feeders, four rotary converters, and the interconnection of the first extension bank of switchgear, situated in the first annexe. The first extension bank of switchgear erected in this annexe controls a third generator rated at 4500 kilowatts, and additional feeders. For this extension a bank of three single-phase, 50-kVA, 3 per cent. series reactors—see Fig. 6—has been installed to keep the maximum short-circuit value within the limits of the rupturing capacity of the oil circuit breakers on the original bank of switchgear in the turbine house.

When the fourth generator, rated at 7500 kilowatts, was put into service, a second extension bank of switchgear was necessary for the control of this machine, and further feeders. This switchgear has been erected in the second annexe, and is a duplicate of that in the first annexe, the two sets of bus-bars being connected by means of a bus-bar cross-over in a stone structure.

Owing to still further demands for power, a third extension bank of switchgear was installed for the control of additional feeders, the fifth generator rated at 10,000 kilowatts, and the sixth generator rated at 20,000 kilowatts. To accommodate this switchgear, another extension, the third annexe, had to be made to the building. From the illustration of this switchgear—Fig. 1—it will be perceived that a glass tread gallery gives easy access to the isolators and bus-bars. The bus-bars connecting those of the second and third banks of switchgear are accommodated in a crossover stone structure that passes through the dividing wall of the second and third annexe. A solenoid operated oil circuit breaker for the 10,000-kilowatt generator, with its oil tank lowering mechanism in position, is shown in Fig. 2; whilst Fig. 3 shows a bus-bar interconnector equipment. Finally, Fig. 4 shows the assembly of the instrument transformers of the 10,000-kilowatt generator equipment. These transformers are housed at the back of the circuit breaker cell, and the large current transformers in the top cells are provided with two secondary windings, one for energising the current elements of the various instruments and relays in the generator circuit, and the other for the generator protective circuit, the voltage elements being energised from the secondaries of the voltage transformers housed in the bottom cells. The smaller current transformers mounted on the side barriers of the top cells are in the high-voltage side of a unit transformer, which supplies the turbine auxiliaries at 400 volts, the low-voltage side of the transformer being controlled from a two-panel B.T.H. switchboard equipped with hand-operated oil circuit breakers, but in the event of a failure on the part of the unit transformer, means are provided for obtaining an alternative supply from the station transformer and interlocks prevent the possibility of paralleling the two supplies.

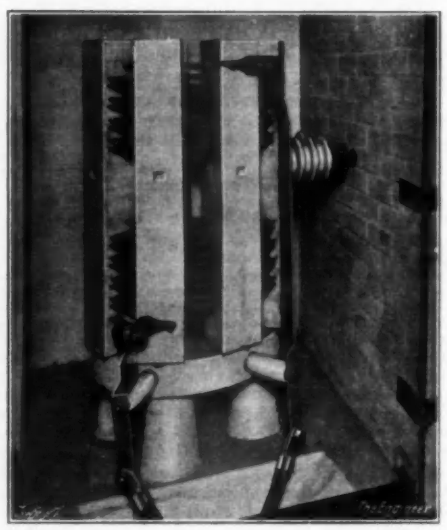


FIG. 6—SINGLE-PHASE REACTOR

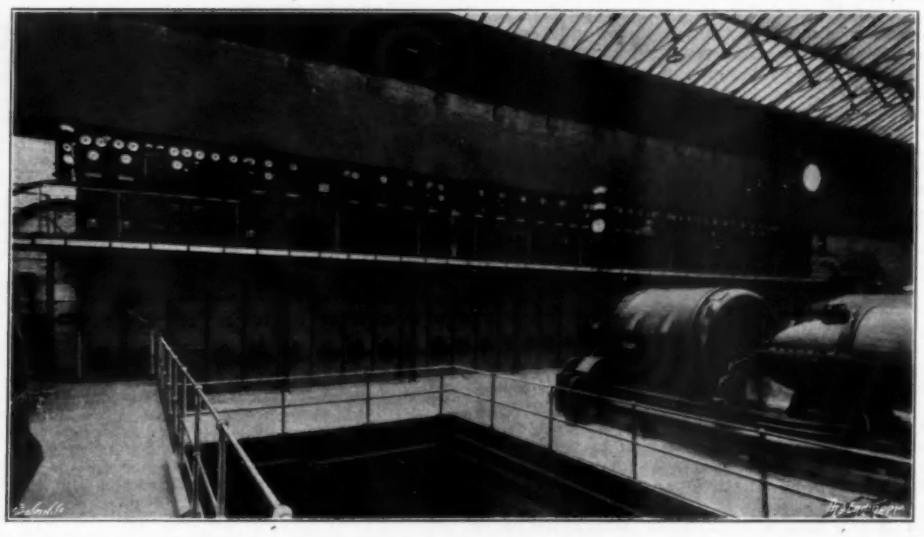


FIG. 5—CONTROL BOARD IN TURBINE-ROOM

Design and Results of a 600 lb. per Square Inch Boiler Installation.*

By WILLIAM NITHSDALE, B.Sc., Associate Member.

(*Concluded from page 357.*)

FOR high pressures, particular attention has to be given to the mountings, especially to the steam fittings. At the same time, it must be remembered that the specific volume of steam decreases as the pressure increases, and in consequence the steam fittings can be smaller. The principal mountings on this plant are :—

Safety Valves.—
One 1¼in. pilot valve with whistle alarm on saturated steam drum ;
One 2½in. double-spring valve on superheater outlet ;
One 2½in. double-spring valve on saturated steam drum ;
Two 2in. single-spring valves on economiser.

These valves are of the Cockburn-McNicoll high-lift type, with cast steel casings and covers and with stainless steel valves and seats. They have sheet steel casings round the springs to induce a cooling air draught through them. It will be noted that the main valve area is distributed equally between the saturated steam drum and the superheater drum. The valve on the latter is set at a lower pressure as a protection for the superheater, to ensure that the flow of steam through the superheater tubes will not be interrupted should the safety valves lift.

Main Steam Stop Valve.—This is a 6in. bore parallel slide valve with steel body and cover, platnam seats and discs and stainless steel belt.

Blow-off Valves.—There are four 1¼in. parallel slide valves with steel bodies and covers and platnum valves and seats. One valve is fitted on each boiler water drum and on the lower economiser drum.

Feed Check Valves.—These are of the 3in. bore, controllable cup, check type, with steel bodies and lids, platnam valves and seats, each with extended spindles and gearing for operation from the firing floor. These valves are of Hopkinson manufacture, the feed check valves being hydraulically tested to 1500 lb. per square inch and the others to 1200 lb. per square inch.

Water Gauge Fittings.—These are of special interest. They are ⅝in. bore with 19in. water level indicators, and were made by Messrs. Dewrance. They are provided with screw-down shut-off valves fitted with renewable valves and seats made of nickel alloy in place of the ordinary asbestos-packed cocks. The valve bodies and covers are

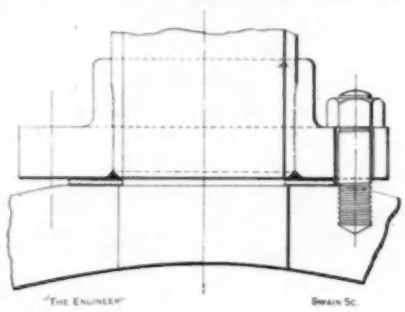


FIG. 5

machined from solid, heavy section, mild steel stampings, and have outside-screw, Monel metal, spindles in order that the threads shall not come into contact with the high-pressure steam or water. The indicator has two specially hardened thick glass plates housed in a box-shaped steel frame, the central web of which keeps the plates apart and forms a space for the steam and water. The joint between the glass plates and main frame is made with special high-pressure packing. A thin sheet of mica is interposed between the glass and the steam and water to prevent the glass plates being dissolved by the action of the steam and water.

Amongst the accessories, each unit has two Parry soot blowers, one in each side furnace wall, which take steam from the saturated steam drum through a separate 2in. bore connection ; one Copes feed-water regulator, and a complete set of measuring and recording instruments.

Some points often raised by prospective users have been discussed already, but a question occasionally arises regarding the type of joint used for high-pressure work. In the plant described, the mountings are attached direct to the drums by studs, the drums being faced to receive the flanges. A serrated nickel steel ring, ⅛in. thick and having fourteen serrations per inch of width, is placed between each valve flange and the drum face inside the stud circle. Fig. 5 illustrates the method of making the joint and shows a saturated steam pipe connection to the drum. The pipe has a screwed flange with the addition of a "V" weld at the face of the joint. All pipe joints are made in the same way.

The principal particulars of the designed performance of a unit are approximately as follows :—

Normal evaporation	61,500 lb. per hour
Working pressure	575 lb. per sq. in.
Steam temperature, approx.	750 deg. Fah.
Temperature of feed inlet to economiser	225 deg. Fah.
Rise in temperature of steam through superheater	264 deg. Fah.
Temperature of gases leaving boiler (designed for 12 per cent. CO_2)	600 deg. Fah.
Temperature of gases leaving boiler (called-for margin)	650 deg. Fah.
Temperature of gases leaving economiser	466 deg. Fah.
Temperature of gases leaving air heater (based on 60 deg. Fah. air)	275 deg. Fah.
Temperature of feed leaving economiser	315 deg. Fah.
Temperature of air entering air heater	60 deg. Fah.
Temperature of air leaving air heater	270 deg. Fah.
Overal efficiency on net or lower calorific value of coal according to Inst. C.E. Report, 1913	86 per cent.

* The Institution of Mechanical Engineers.

Gross overall efficiency	82·5 per cent.
Calorific value of coal	10,000 B.Th.U. per lb.
Grate area	324 sq. ft.
Coal per square foot of grate area	27·5 lb. per hour
B.Th.U. per square foot generating surface, approx.	5,500 per hour
B.Th.U. per square foot superheating surface, approx.	3,000 per hour
B.Th.U. per square foot economiser surface, approx.	1,000 per hour
B.Th.U per square foot air heater surface, approx.	450 per hour
B.Th.U. released per cubic foot of combustion chamber, approx.	20,000 per hour
Average gas velocity through economiser, approx.	17·5ft. per sec.
Average gas velocity through air heater, approx.	15ft. per sec.
Average air velocity through air heater, approx.	12ft. per sec.
Average air velocity through air ducts, approx.	30ft. per sec.
Average steam velocity through superheater, inlet nest, approx.	32ft. per sec.
Average steam velocity through superheater, outlet nest, approx.	35ft. per sec.

The overload evaporation is about 77,000 lb. per hour, for which the following are approximate designed figures :

Net overall efficiency according to Inst. C.E. Report, 1913	83·5 per cent.
Gross overall efficiency	80 per cent.
Coal per square foot grate	36 lb. per hour

The fans have ample overload capacity, their ratings being shown in the following tables :—

Forced Draught (one per boiler unit).

	Cu. ft. air per min.	Water gauge, inches.	Temp., deg. F.	R.p.m.	B.H.P.
Normal	30,000	2·7	60	585	27
Overload	40,000	4·75	60	775	61
Overload	43,000	5·0	100	835	68
Overload	45,000	5·5	100	870	79

Induced Draught (one for two boiler units).

	Cu. ft. gases per min. each unit	Water gauge, inches.	Temp., deg. F.	R.p.m.	B.H.P. two units
Normal	44,000	1	300	220	30
Overload	62,000	2	350	315	80
Overload	66,000	2	400	325	85

The pressures at which the safety valves were originally set to lift were as follows :—

	Lb. per sq. in.
Pilot valve on saturated steam drum	580
Main valves on superheater drum	595
Main valves on saturated steam drum	600
Economiser relief valves	610

These proved for convenience in operation to be too close to the working pressure, the margin being hardly sufficient to keep the valves tight under running conditions, and, in consequence, the settings were all made 10 lb. per square inch higher than those stated above.

The speed of the steam through the superheater may be considered to be rather low, but a high steam velocity necessarily involves a large pressure drop. Good design, it is felt, should aim at a steam speed as low as possible, compatible with keeping the tube temperature at a safe figure. Right-angle bends in superheater tubes should preferably be avoided, so that the tubes are evenly "washed" by the steam with a minimum amount of wrenching. The tube walls are thereby maintained at a temperature close to that of the steam which forms the cooling medium.

The object of the pilot valve alarm is to give warning well before the main safety valve blow-off pressure is approached, and so to avoid the main valves lifting other than in exceptional instances. Below the pilot valve is a small forged steel stop valve, which can be shut if the pilot valve gets cut by the high-pressure steam and needs repair, a spare pilot valve being carried.

When commencing this paper it was thought to include a series of test figures taken under actual trial conditions, but the Alkali Company have very kindly proffered results taken under ordinary running conditions by their own staff long after the plant was taken over. These, it is thought, are of more value and will be of greater interest than trial results. Nowadays there is a tendency to publish boiler efficiency figures which have only been obtained with plant thoroughly cleaned and carefully tuned beforehand. Commercial figures from everyday experience are of far greater consequence and the true criterion of the merit or demerit of an installation.

This plant has to operate for long periods continuously day and night, and the following are the user's averages of typical observations for a week about the middle of a usual steaming period :—

Evaporation per hour	61,000 lb.
Working pressure	552 lb. per sq. in. gauge
Steam temperature	755 deg. Fah.
Feed temperature	241 deg. Fah.
Coal burned per hour	7150 lb.
CO_2 at air heater exit	10 per cent.
Temperature of gases leaving boiler	650 deg. Fah.
Temperature of gases leaving economiser	465 deg. Fah.
Temperature of gases leaving air heater	295 deg. Fah.
Temperature of air entering air heater	70 deg. Fah.
Temperature of air leaving air heater	251 deg. Fah.
Temperature of air at stoker wind boxes	251 deg. Fah.
Temperature of feed entering economisers	241 deg. Fah.
Temperature of feed leaving economisers	316 deg. Fah.
Air pressure forced draught fan discharge	3·36in. water
Air pressure stoker wind boxes	0·69in. water
Induced draught fan suction inlet	1·90in. water
Suction in furnace	0·09in. water
Forced draught fan motor input	26·5 kWh
Induced draught fan motor input	29 kWh
"Riddlings" per hour	20 lb.
Calorific value of "riddlings"	3380 B.Th.U. per lb.
Ashes per hour	770 lb.
Carbon in ash	15 per cent.
Calorific value of coal, gross	12,020 B.Th.U. per lb.
Coal analysis—	
Ash	6·3 per cent.
Moisture	8·8 per cent.
Volatile matter	29·0 per cent.
Fixed carbon	53·9 per cent.

Ultimate analyses of coal from the dump gave 3·5 to 3·75 per cent. hydrogen present.

These results, it will be noted, were taken at a load very close to the designed normal, the working pressure being on the low side. The CO_2 percentage is low at the air heater exit and probably was not much higher in the furnace as the whole plant is steel cased. An exit gas temperature of 650 deg. Fah. shows that the conjectures made in calculating boiler surface were not far out. The rise in feed temperature through the economiser is less than anticipated, but at the same time the inlet temperature of the water is appreciably higher than allowed for and handicaps the economiser somewhat. In the air heater the rise in air temperature/drop in gas temperature ratio corresponds to the designed figure, although the performance is rather less. This can be explained partly by the higher air temperature at entrance and partly by the lower CO_2 percentage, the latter involving a larger weight of gas and air flowing through the heater and having the same effect as reducing the surface. At first sight, one might be sceptical of the statement that no heat appears to be lost in the hot air ducts leading to the grates. Radiation is bound to take place in spite of the efficient lagging, but some heat will be imparted to the air where the main duct adjoins the boiler casing, balancing the heat lost by radiation. The quality of the coal is better than the basis, but this means that the stoker is burning well below its designed normal amount per square foot, and is thereby handicapped in obtaining the best result, although it is of the compartment type. The amount of "riddlings" is so small that it may be neglected. From the above figures the following may be deduced, taking the specific heat of dry flue gases as 0·248, the percentage of hydrgen in the coal as 3·5, and the "ideal" CO_2 percentage as 18·5 :—

	Approximate percentage.
Heat realised in steam	83·8
Heat lost due to free H_2O in coal	0·9
Heat lost due to unburnt carbon in ash	1·9
Heat lost in dry gases	6·8
Heat lost in moisture formed from hydrogen in coal	3·0
Radiation and unaccounted for	3·6
	100·0

Of the B.Th.U. amounting to 83·8 per cent. of the total, which are transferred to the water after it enters the economiser, there are :—

	Per cent
In the economiser	5·3
In the boiler	66·8
In the superheater	11·7
	83·8

The rates of heat transfer work out at :—

	Per hour.
B.Th.U. per square foot economiser surface	835
B.Th.U. per square foot generator surface	5450
B.Th.U. per square foot superheater surface	3100

while the rise in feed temperature/drop in gas temperature ratio is 0·405 for the economiser, and the rise in air temperature/drop in gas temperature ratio is 1·06 for the air heater.

The loss due to unburnt carbon in the ash is high, and was probably occasioned by the fire being carried rather far down the grate in endeavouring to get the full benefit of radiation from the incandescent fuel bed.

The overall efficiency on the gross calorific value of the coal as fired—shown above—is 83·8 per cent. and corresponds to the gross overall efficiency as defined in the latest Heat Engine Trials Committee report of the Institution of Civil Engineers, dated 1927. The designed figure, it will be remembered, is—on the gross calorific value of the coal—82·5 per cent.

The power absorbed by the stoker motors is very small, and was not measured. Adding an outside figure of 2·5 kW hours for the stoker drive to the power consumption of the fans, and assuming 15,000 B.Th.U. are taken per kilowatt-hour, the heat absorbed by these auxiliaries amounts to about 1 per cent. of the total released in the furnace. (The induced draught fan overcomes the resistance through the flues in addition to that across the unit.) The net overall efficiency on the gross calorific value of the coal, debiting the power absorbed by the fans, is therefore 82·8 per cent.

The overall efficiency based on the net or lower calorific value of the coal as defined in the Institution of Civil Engineers code of 1913, is 87 per cent.—with 3·5 per cent. of hydrogen—which is 1 per cent. higher than the guarantee. This figure does not take into account the power absorbed by the fans.

It is difficult to say exactly how much of the 83·8 per cent. gross overall efficiency is due to the air heater, as the latter forms part of the combustion cycle and is not a direct absorber of useful heat. Assuming, however, that without the air heater the gases left at the present economiser exit temperature, the additional heat loss in dry gases, in free moisture, and in moisture due to hydrogen would amount to about 5 of the 83·8 per cent.; that is, the gross overall efficiency would be reduced to 78·8 per cent. There would be less fan power, but in all likelihood a lower percentage of CO_2 would result, combined with a relatively higher exit temperature.

The satisfactory efficiency maintained in service with the fairly low percentage of CO_2 shown in these results shows that the plant has a reasonable performance margin in hand. It should be an axiom in all boiler design to be on the liberal side where performance is concerend, and in this respect the encouragement of extreme competition becomes detrimental if it leads to the designer being so handicapped by purchase price that he can only afford to aim at the bare guarantee.

No special comments seem called for in connection with the operation of such a high-pressure boiler, and the boiler-house engineers say that the plant is just as easy to run as their low-pressure boilers.

Priming had been suggested as a possible source of anxiety, it being argued that because of the lower density difference between water and steam at higher pressures more water would be carried over by the steam. Experience does not bear this out, and probably the fact that

the steam bubbles are smaller at higher pressures minimises any tendency to the entrainment of water. Coning should where possible be hydraulic. Up to 1200 lb. to 1400 lb. per square inch high pressures present little

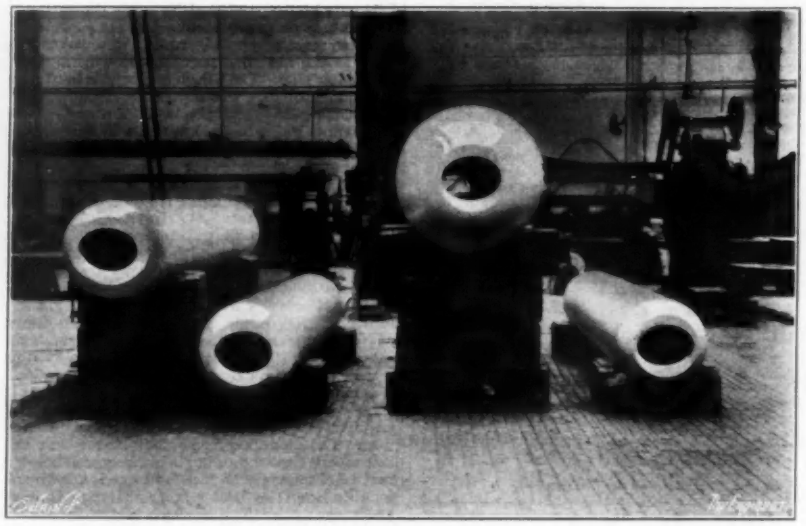


FIG. 6—DRUMS FOR A WORKING PRESSURE OF 1200 LB. PER SQUARE INCH

fidence is felt in the immunity from priming of the design described, as many boilers of similar form work satisfactorily in the Navy at rates of evaporation up to 24 lb. of water per square foot of surface, three or four times the rate usual in land practice.

At the same time it is probable that very quick changes in load should, where possible, be avoided in the operation of any high-pressure boiler. To keep thicknesses within reasonable limits the tendency is to have smaller steam drums, and this is in part justified by the lower specific volume of high-pressure steam, which therefore requires less steam space. When a boiler is steaming at a high rate a good proportion of the water volume in the saturated steam drum is taken up by steam bubbles which contract rapidly and cause the water level to fall if the output is reduced. If the volume of water is then increased by opening the feed regulators wide and this is followed by rapid steam raising, raising the water level still further, there is risk of the steam becoming unduly wet for a brief interval until the water resumes its proper level.

Other causes of priming, apart from the presence of water, containing oil or soapy impurities which will make any steam-raising vessel prime, can usually be traced to the design of a boiler. For instance, a boiler with several saturated steam drums is liable to prime at times when the load is changing, due to slight pressure differences arising between the drums; 1 lb. per square inch pressure is equivalent to nearly 2ft. head of water. Varying areas in the water path giving rise to different velocities during circulation are other possible causes.

Judging by past experiences, one might say that boiler drums with both longitudinal and circumferential seams riveted are suitable for pressures up to 450 lb. per square inch and that forged drums with riveted ends are suitable up to 650 lb. per square inch, while above 650 lb. per square inch it would appear best that drums should be entirely forged. Intermediate circumferential seams should, of course, be avoided at all costs, irrespective of pressure. The number of bolted joints should be kept

difficulty, and steel makers are now producing forged drums having an ultimate strength of 34 to 38 tons per square inch which are specially suitable for high-pressure work and which enable the metal thicknesses to be kept down to an absolute minimum. Only the very highest class of workmanship can safely be accepted and any riveting should where possible be hydraulic. Up to 1200 lb. to 1400 lb. per square inch high pressures present little difficulty, and steel makers are now producing forged drums having an ultimate strength of 34 to 38 tons per square inch which are specially suitable for high-pressure work and which enable the metal thicknesses to be kept to a minimum. Fig. 6 shows the drums—of steel of 34 to 38 tons per square inch—for a Yarrow boiler with a working pressure of 1200 lb. per square inch now actually completed and undergoing an exhaustive series of tests.

A steam temperature of well over 800 deg. Fah. has been recorded occasionally on the installation at Runcorn, but at the same time concern is felt for ordinary commercial steels at much above this temperature in view of the lowering of strength which occurs at about 850 deg. Fah. and above. Reduction of the stress by thickening the tubes only leads to a vicious circle, as the thicker wall gives rise to a higher metal temperature. For steam temperatures above 800 deg. Fah. special alloy steel superheater tubes are recommended for the last passes and suitable tubes of chrome-nickel steel are becoming procurable.

Pressure imposes no reasonable limit on the possible size of a steam generator, thanks to the development of solid forged drums by steel manufacturers, and Fig. 7 shows a unit for an output of 250,000 lb. per hour at a pressure of 800 lb. per square inch pressure and a steam temperature of 800 deg. Fah. To get the necessary surface in a medium furnace width two saturated steam drums are proposed. Liability to prime for the reasons previously stated is mitigated by the crossed arrangement of fire-row tubes, which, it is thought, would ensure equal pressures in the two steam drums at all times. The superheater is shown in two elements, one element at the front and the other at the back of the unit. Each superheater element has two drums with only vertical internal divisions. This design embodies a completely water-cooled furnace for pulverised fuel firing, the side walls being of special form for high-pressure work. Fig. 8 shows the principle of these walls, which are an extension of boiler generating surface rather than a new section added to the unit. Mechanical stokers could be fitted in place of pulverising equipment if preferred in the unit shown in Fig. 7. Suitable drums can be obtained 40ft. in length and even longer, and there is nothing to hinder a high-pressure boiler on the lines of that illustrated in Fig. 7 being confidently put forward for 500,000 lb. per hour output.

In conclusion, the author acknowledges his indebtedness to Messrs. Yarrow and Co. for authority to prepare this paper, and to the Castner-Kellner Alkali Company for the figures they have so kindly supplied.

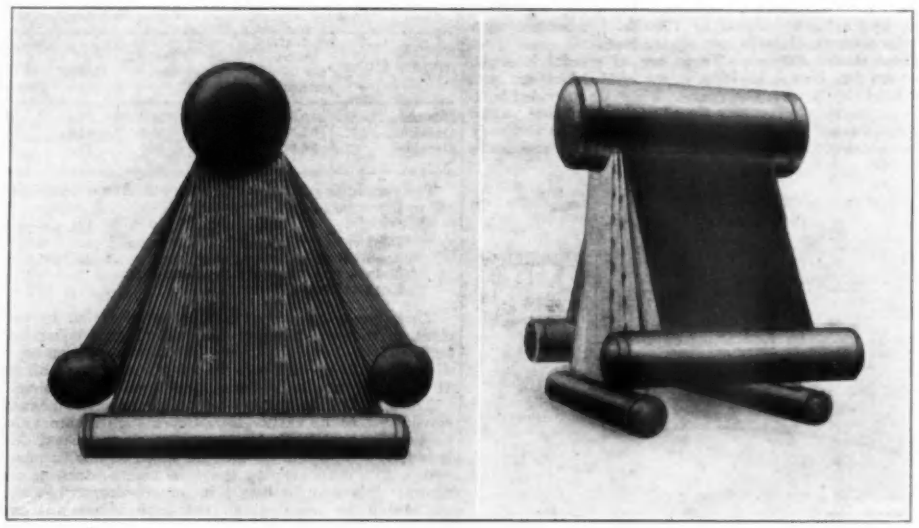


FIG. 8

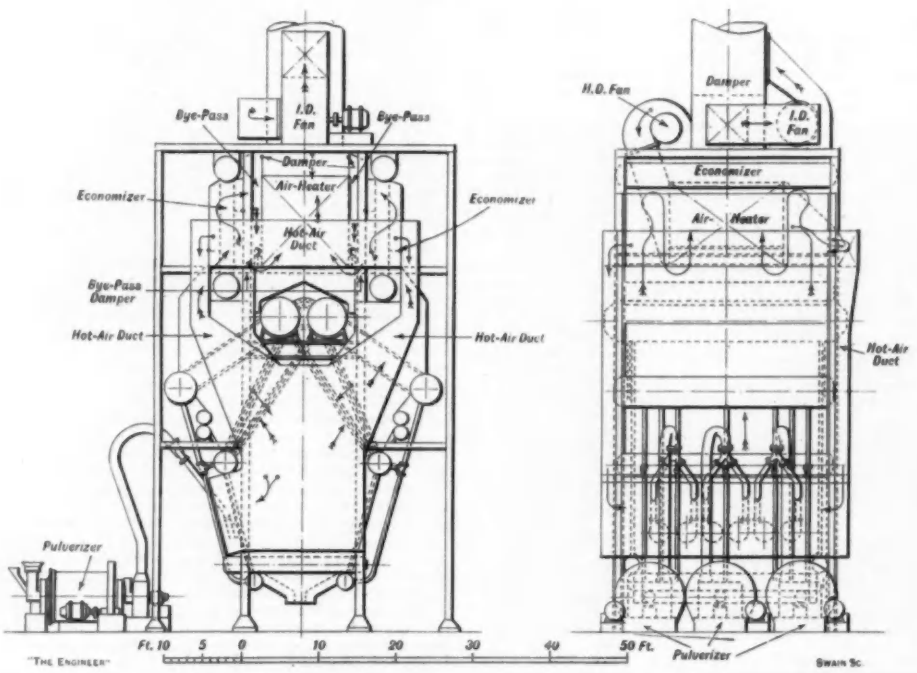


FIG. 7—WATER-TUBE BOILER WITH SUPERHEATERS, ECONOMISERS AND AIR HEATERS

MARINE OIL ENGINE INSTALLATIONS.

A PAPER on marine oil engines was read before the Manchester Association of Engineers on Friday, 28th ult., by Mr. J. Calderwood, M.Sc. The author said that at the present time, for the slower classes of cargo vessels, the shipowner frequently considered the first cost before anything else, and as a result resorted to steam engines on routes on which the internal combustion engine could be adopted with considerable advantage in service economy. The high first cost of the oil engine ship of that type was largely due to the auxiliary machinery, and unless the cost of that plant could be considerably reduced the steam engine was likely to retain its predominance. A fault of many auxiliary installations was the over-elaboration of the arrangement of the pumps, separate units being provided for services that could be run in conjunction and every pump being duplicated, one unit being capable of the full normal duty, while the second was available as a standby. In addition, cross-connections were provided so that the pumps for one service might be used as additional standby for some other duty. Such elaboration greatly increased the cost of the machinery and gave little, if any, extra reliability to the installation as a whole. With care in design the auxiliary pumping installation might be greatly simplified, one pump being used for more than one service, while, by suitable cross-connection, a single standby unit might serve two or more auxiliary systems. With steam auxiliaries, for instance, the engine-cooling system might be arranged so that a part of the water going to the engine could be used in the oil coolers, while the overboard discharge from either piston or jacket cooling might serve the auxiliary condenser. A single pump could, in such an installation, serve as standby for the combined cooling system, for the ballast system and for the bilge service. Another direction in which there were possibilities of saving in the cost of marine installations was by the standardisation of parts of the engine-room equipment, such, for instance, as fuel tanks, filters, air bottles and silencers. Plumbers' and fitters' work could be economised by standardising oil and water connections and piping, while the cost of pumps could be reduced by adopting standard positions for the branches on the pumps.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE ROLLING OF METALS.

SIR,—I have been greatly interested in the articles now appearing in THE ENGINEER on "The Rolling of Metals," by Mr. J. Selwyn Caswell.

In your issue of February 28th, however, giving his treatment for finding the position of the no-slip zone, he makes an assumption that appears to be incorrect. Referring to Fig. 5, he says :—"For the passage of equal volumes across $a\,a$ and $b\,b$ the slip volumes must be equal." In other words, he makes the statement that the slip volume at entry of the stock should be the same as the slip volume at exit.

Equal volumes must obviously pass any section plane during rolling, if the metal suffers no change in volume, but it does not follow that equal *slip* volumes also pass the entrance and exit sections. A. W. KNIGHT.

Ipswich, April 2nd.

SIR,—I have been reading with the greatest of interest the series of articles which are appearing in your issues on the above subject by Mr. J. Selwyn Caswell, and would congratulate the author on his comprehensive theoretical study of the subject, which is of special interest to myself.

Unfortunately, the rolling process, especially with cold rolling, is not easily analysed mathematically, and I have found in my experience that conclusions reached after the most careful theoretical investigations are not correct, and are not in agreement with experimental results.

Some of the conclusions stated by Mr. Caswell are no exception, and whilst I have not as yet had time to study the whole of the articles in detail, I have already come across one or two points on which I am obliged to disagree with your contributor. They are mainly in connection with the section dealing with the movement of the stock between the rolls on pages 232 and 233—issue of February 28th. Referring to Fig. 2, the vertical velocity of a point on the roll periphery is correctly given as $\omega\,r\sin\alpha$, or, approximately, $\omega \cdot r \cdot \alpha$, but it is stated that twice this speed is the rate of deformation of the stock. This assumes that the velocity mentioned above is that of a particle of the stock itself, whereas it is, of course, only the velocity of a point on the roll surface. It is not correct to state that the rate of deformation is $2\,\omega\,r\,\alpha$ unless it is assumed that the horizontal velocity of the stock is $\omega \cdot r \cdot \cos\alpha$; that is to say, the speed of the stock corresponds with that of the roll periphery. This, as Mr. Caswell later points out, is only true at one point on the arc of contact. The rate of deformation is, in my opinion, a very important factor in the rolling process and must be based on the actual speed of the stock.

This brings up the second question, namely, the entry and exit speeds of the stock. Mr. Caswell concludes that the point where no slip occurs between roll face and stock lies between the point of entry and exit, and on page 233 gives a formula (4) from which is obtained the value of the angle which determines the point of no slip.

From this he gives formulæ 5 and 6, which are stated to give the speeds of the stock at entry and exit without going into the mathematics on which the conclusions listed on page 260 are based. It is certain that with the cold rolling of the harder metals, such as steel, brass, copper, &c., the point of no slip is very approximately, if not exactly, at the point of exit; that is to say, that the speed at which the metal is delivered from a pair of rolls is very closely equal to that of the peripheral velocity of the rolls, and it is certain that it is never so greatly in excess of the rolling speed as is indicated by the formula deduced by the author. The only case in which the delivery speed is approximately greater than the surface speed of the rolls is in the rolling of soft metals, such as tin and lead. With these metals and their alloys the extrusion effect is considerable.

I believe the flaw in Mr. Caswell's reasoning is that he assumes that the intensity of pressure over the constant arc is uniform, whereas with all metals which harden appreciably with cold working this intensity increases from entry to exit, reaching a maximum at the latter. From this it is very clear that it will be exceedingly difficult for the metal to slip forward, in advance, on the rolls at this point, and it follows that the point of no slip must be where the intensity of pressure between roll and stock is the greatest. In any case, this reasoning is confirmed by experimental results not only in regard to the harder metals and alloys, but with the case of tin and lead, for as these latter do not harden appreciably by cold working, the intensity of pressure is more nearly uniform over the constant arc, and, consequently, the exit speed is frequently much greater than the peripheral velocity of the rolls.

With these metals the point of no slip must lie between entry and exit points as assumed by Mr. Caswell, but even here the actual entry and exit velocities do not agree with those calculated by his formulæ.

Even more important than the above is the question of the effect of rolling speed on roll pressure required, and, consequently, power consumption. On page 261—March 7th—it is stated that the resistance to deformation increases with the speed, consequently it would be inferred that the power required increases at a greater rate than that at which the rolling speed is increased. This certainly would appear to be reasonable, but, again, recent experience has shown that the power consumption for any given reduction does not increase with the speed, and it would appear at least for some metals that the resistance to deformation is less at higher speeds than at lower.

It is, I believe, a case of critical velocity; that is to say, there is a speed which is most economical for any particular metal or alloy, and generally this most efficient speed is well above the usual speeds adopted in cold rolling. Such experiments as have been made to determine the efficiency of increased rolling speeds have not been conclusive, as it is difficult to get all conditions—bearing friction, &c.—the same when carrying out practical trials; but my recent experience with high speed rolling has given astonishing results, in that the power consumption is very considerably less than would have been expected at the increased speed.

Whilst I feel obliged to criticise Mr. Caswell's articles, I shall continue my study of his work which cannot but help forward the scientific understanding of this important subject, which has hitherto not received the attention it deserves.

C. E. DAVIES,
Director, W. H. A. R. and Co., Ltd., Bedford.

Bedford, March 26th.

THE UNEMPLOYMENT PROBLEM.

SIR,—You raise the question in your issue of March 14th, under the above heading, as to whether unemployment is not due to the world being unable to consume what it can manufacture.

May I point out that the cause of unemployment is due to a misunderstanding of economic laws? We have the impression in this country that our present troubles are due to lack of export orders, and our efforts are devoted to endeavouring to increase our overseas sales. The facts are that we are doing all the foreign trade we need. We not only pay for all our food requirements and raw materials, but also succeeded in investing abroad in the year 1927 some £114,000,000, in 1928 £150,000,000, and in 1929 £152,000,000. In the same period the foodstuffs bought abroad provided about 50 per cent. more meat, butter and other foods per person; in short, the standard of life has improved enormously, so far as foreign produce is concerned.

The only reasonable conclusion to come to is that our foreign trade is quite satisfactory, but that where we are at fault is in our home trade. We have the requirements to create a booming home trade, viz., great wants and desires on the one hand, and labour and materials in abundance, and, in addition, capital in the form of idle works. What we lack is credit, and this can only be provided by a proper handling of economic laws. We are wrong in our outlook on economic matters; in short, we are hopelessly ignorant of economic science. In physical science we are second to no other nation.

You are right in saying that the X-rays of economic research must be applied without political prejudices.

E. R. SUTCLIFFE.

London, S.W. 1, March 29th.

MORE BRITISH SLACKNESS.

SIR,—I have just received a letter from my son—not a new settler, but one of ten years' experience—from Tanganyika, in which he gives the following illuminating example of how difficult it is to do business with British firms.

He writes: "I am having the greatest difficulty in buying machinery, because the makers only send out bits of their catalogues, and will not quote any prices. It costs several pounds to get the cost of each machine by cable. And all this talk about 'Buy British.' Why you can't do it. What are the manufacturers afraid of? They even send their own agents catalogues only. They just deserve to sell in England only. Here is a picture of the first of my new machines. I want to order some more, but they will not tell me the price. They send out a catalogue like this (prices on application), after my ordering this machine and cabling for full details of all their machines. Do they think I shall cable for each price separately? I have already placed an order for about £120 worth of saws with another firm, because they sent a catalogue with prices in it. The goods are not so good as ———'s, but I wanted them quickly."

Supplementary to my son's complaint, may I add one of my own?

In Mombasa in 1925 we received a beautifully got-up folder advertising cranes for motor garages, "prices on application." Six weeks' delay, awaiting reply and price. It came. It said: "We always send our advertising matter like this because it creates inquiries." And still no price enclosed.

ERNEST MORISON.

London, N. 12, March 28th.

The Transmutation of Matter.*

THE idea that one metal could be transmuted into another first arose among the Greeks in Alexandria in the first few centuries A.D. and spread through Europe in the Middle Ages. The search for the Philosopher's Stone, by the help of which one metal could be converted into another, was pursued with confidence and hope under the direct patronage of princes and rulers, who hoped in this way to restore their finances. Although the evidence in its support was meagre and doubtful, this idea of transmutation was very widespread, for it not only accorded with the desires of man, but was supported by the philosophic conceptions of Aristotle.

It does not appear to be generally known that our King Henry VI. was a convinced believer in the doctrine, and at the time of the Wars with France gave patents about 1440–50 to a number of Englishmen to convert the base metals into gold. As a result a new coinage was struck called the "rose noble," which was distributed in France through Calais and to Scotland over the Border. The Scots promptly retaliated by legislation to avert this danger of the introduction of a debased coinage.

With the growth of chemistry in the 18th and 19th Century and the proof that matter was composed of a number of distinct unchangeable elements, the idea of transmutation receded, but the possibility of a primordial type of matter was never completely abandoned. The discovery of the periodic relationship in the properties of the elements revived the belief in transmutation, and Faraday remarked: "To decompose the metals, to reform them and to realise the once absurd notion of transmutation—these are the problems given to the chemist for solution."

The proof, in 1903, that the heavy radioactive elements were undergoing spontaneous transformation with the emission of new radiations of a powerful type was an event of great importance, but it was soon shown that this radioactive property was confined to a few elements only and that the great majority of the ordinary elements appeared to be permanently stable. In the meantime, there was a rapid increase in our knowledge of the structure of atoms, and it became clear that in order to produce a permanent change in an atom, it was necessary to remove, or add, a charged particle to the minute charged nucleus which governed the properties of an atom. In 1919, Rutherford showed that some of the nuclei of the atoms of nitrogen could be transformed by bombardment with the swift α particles emitted by radium. Subsequently, Rutherford and Chadwick found that a number of the lighter elements showed a similar effect, and in all cases a swift proton was found to be emitted in consequence of a violent collision between an α particle and the atomic nucleus. Our evidence indicates that in the case of nitrogen the α particle is captured during this process and the mass of the resulting atom is greater than before. These effects manifest themselves on a very small scale and in general only about one α particle in 100,000 comes close enough to a nucleus to effect its disruption.

Transformation of an atom would occur also if an electron could be forced into a nucleus. In recent years, numerous experiments have been made to change mercury into gold and lead into mercury by means of intense electrical discharges, but there is no certain evidence that any transmutation occurs by this method.

There appears to be little doubt that, if sufficiently energetic atomic projectiles were available, many of the elements could be transmuted, but only on a minute scale.

Apart from the radioactive bodies, it now seems clear that a large amount of energy must be applied to produce a disruption of the nuclei of the ordinary elements. The old idea that a new source of energy could be tapped by transformation of the ordinary elements now seems untenable. There remains, however, one interesting possibility. If hydrogen nuclei—protons—could be made to combine to form a nucleus of helium an enormous amount of energy should be emitted during the process. Unfortunately, there is as yet no evidence that such a combination could be produced under conditions available in our laboratories. There seems to be clear evidence that the processes of disintegration and reformation of the atoms of the elements must be occurring in hot stars, but as yet we have no idea of the conditions requisite for such changes.

* From a lecture delivered at the Royal Institution by Sir Ernest Rutherford, O.M., Pres. R.S.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

T. BALMFORTH AND CO., Ltd., have changed the address of their London office to 36, Queen-street, E.C. 4. Telephone: City 5252.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has changed the address of its Leeds office to Permanent House, The Headrow, Leeds.

WE are asked to state that all inquiries and orders for new Clayton machinery and spare parts for existing machines should now be addressed to Clayton and Shuttleworth, Ltd., at Carr House Works, Gainsborough.

ALFRED HERBERT, Ltd., Coventry, inform us that contracts have just been let for an extension to the firm's main machine shop, which at present consists of twenty-three bays. Four new bays are to be added, 517ft. long by 30ft. wide. This is an addition of 1·24 acres, making the total area of the extended shop 8·37 acres.

CONTRACTS.

THE WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, Ltd., has received an order from the Metropolitan-Cammell Carriage, Wagon and Finance Company, Ltd., for 150 vacuum brake sets for wagons for the Buenos Aires and Pacific Railway, each set to comprise two "Prestall" vacuum brake cylinders.

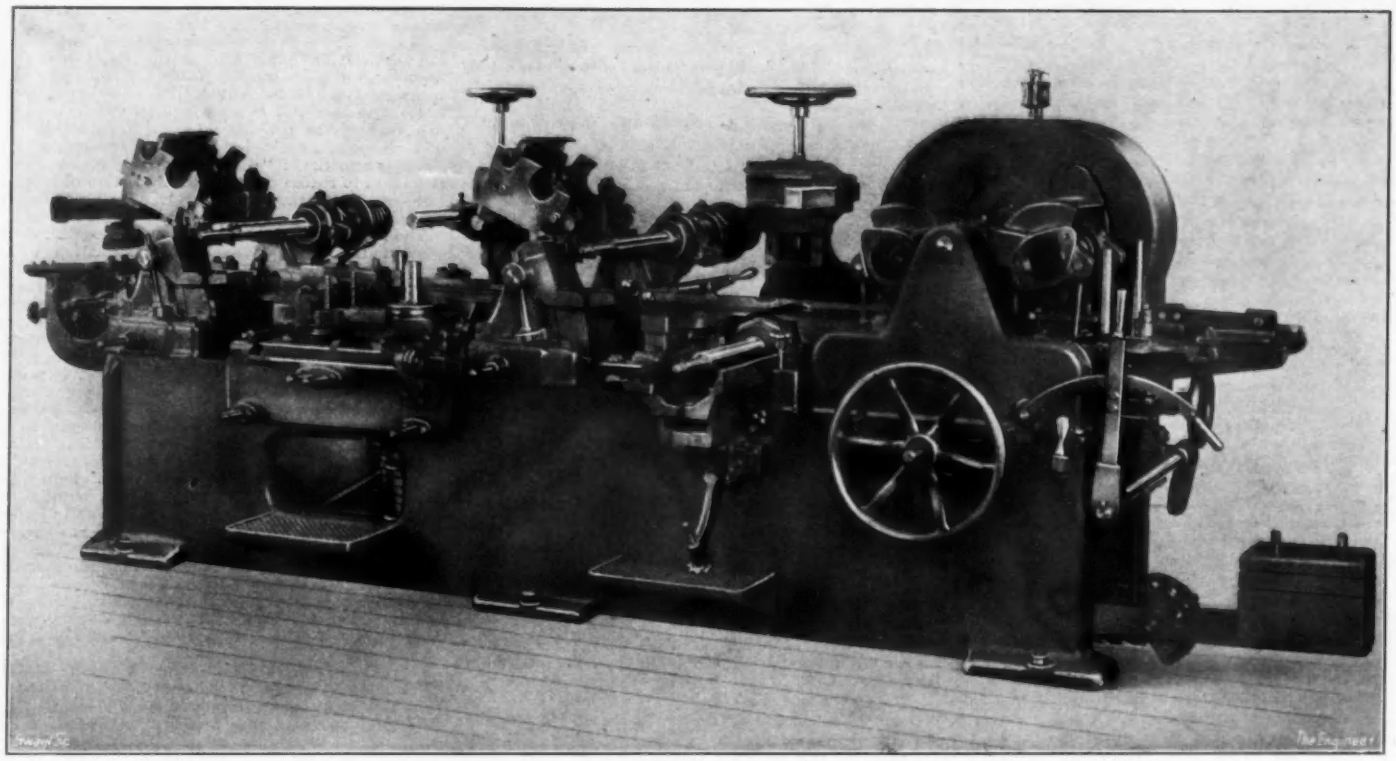
JOHN BROWN AND CO., Ltd., Sheffield, have received orders for a total of twenty-five seamless hollow forged drums, required for Stirling high-pressure boilers in connection with the super-power station at Thornhill of the Yorkshire Electric Power Company, and the extension of the Sheffield Corporation boiler installation. The total value of these orders is over £25,000.

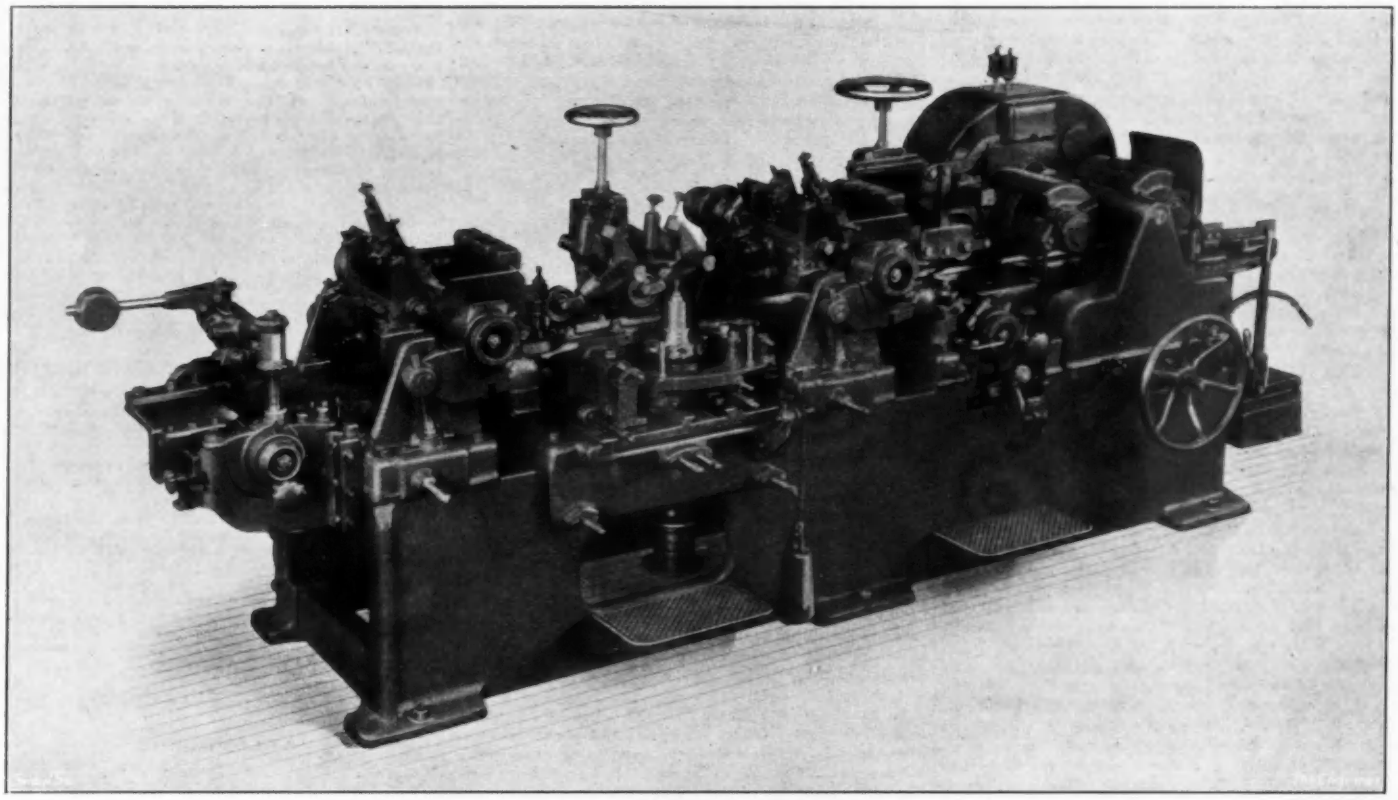
ROYCE, Ltd., Manchester, have received the contract for supplying and erecting the steel work of a new building at Erith, Kent, for the British Fibrocement Works, Ltd. The building will be 280ft. long by 105ft. wide, and is to consist of seven bays. The company has also recently received an order to supply and erect steel work for the Manchester Corporation (electricity department) Cumberland-street sub-station.

THE ENGLISH ELECTRIC COMPANY, Ltd., informs us that it has recently received contracts for 450 hand-operated cam shaft tramcar controllers for Glasgow Corporation; the value of the contract is £26,000; ninety-four "maximum traction" type tramcar trucks fitted with roller bearings, 28in. diameter driving wheels, 4ft. 6in. wheel base, for the Union Construction Company, for service on the London United Tramways; the value of this order is about £14,000; three additional double-deck "English Electric" omnibus bodies to seat fifty passengers, mounted on A.E.C. Regent chassis for the Newcastle Corporation.

TIMBER MOULDING, PLANING AND MATCHING MACHINE

THOMAS ROBINSON AND SONS, LTD., ROCHDALE, ENGINEERS





Timber Moulding, Planing and Matching Machine.

A NEW high-speed machine specially designed for the production of standard mouldings in either hard or soft timbers and for giving a high degree of finish at rates of feed up to 260ft. per minute has recently been introduced by Thomas Robinson and Sons, Ltd., Rochdale. The remarkably high speed at which this machine operates is made possible by many new features which are embodied in the design, in addition to the massive proportions of the spindles and ball-bearing mountings. The machine is particularly intended to deal with bevel sawn stock, a common requirement in this country, owing to the saving of timber which this form of section renders possible.

Among the salient features of the machine—illustrations of which are given above—mention should be made of the ease with which the cutter heads on the various spindles can be changed, the front bearings being removable by releasing two nuts, leaving the spindle undisturbed. The horizontal spindles are each mounted in three ball bearings, two of which are provided at the driven end. Messrs. Robinson employ for the vertical spindles their wide flat mounting, similar to those which have already been described in THE ENGINEER. Vertical adjustment is provided in addition to horizontal and quick-acting locks, all being controlled from the front of the machine. The "pressures" are speedily adjusted for either flat or bevel sawn material, and where rollers are used in the pressures they are carried in ball bearings. The pressure pads can be quickly changed.

All the cutter heads are fitted with self-centring bushes, which enable the cutters to be set up, balanced, and even trued in the toolroom while still ensuring correctness. Jointing devices for truing up the cutters when in position on their spindles are provided. This arrangement enables the heads to remain undisturbed for long periods and the jointing system ensures that each cutter performs its fair share of work. The entire feed system is mounted on ball and roller bearings and roller chains are used for driving. The feed rollers, of which there are four, are 10in. diameter. They are easily removed and replaced for dealing with bevelled timber, since the withdrawal of the bearings and shafts of the top rollers is readily effected. It will also be noted that all the driving mechanism is arranged at the back of the machine. For dealing with foreign sawn hardwood boards and scantlings the bottom rollers have means for simultaneous vertical adjustment with the table directly in front of the bottom cutter head, so as to vary the thickness of the cut. Another feature of special note is the means of adjusting the lever type roll-weighting system whereby the angular movement of the weights is minimised.

The machine is built with four, five or six rotary cutter heads, as required, and the makers recommend the arrangement of two top horizontal spindles, as the heavy work which usually falls on the top cutters can be divided between the two heads, or if desired one head can be set up for working the plain surface and the other for the curved portions of any particular moulding. Similarly, by the provision of two bottom heads,

one can be used for splitting mouldings by means of saws.

The variation of the feeds is effected by means of a three-speed gear-box and a set of three-cone pulleys giving nine rates of feed which vary between 25ft. and 260ft. per minute. This system of driving is claimed to give a better progression of feed speeds and a more efficient arrangement of gears than is possible with a nine-speed gear-box with a ten-to-one range. The three speeds in each group are fairly close together and do not overlap those of any other group. A close selection of feeds for any particular work is thus available.

The equipment of cutter heads provides for a wide range of operations from square-headed cutters for short runs to six-bit profile heads carrying serrated back cutters milled on the back to give a constant profile and long life to the cutter. The belts are of liberal width and the pulleys are as large in diameter as is practicable, considering the high belt speeds employed.

The same machine is also built with self-contained electric motors for each spindle and all controlled by automatic contactor gear operated by push buttons. In this arrangement the motors are designed to give speeds ranging from 3000 to 6000 revolutions per minute by varying the frequency. The feed motor for such machines is of the three-speed variety, or if desired a single-speed motor with belt cones to operate in conjunction with the gear-box mentioned may be used.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Steel Doors, Chairs, and Roofs.

THE Comptroller-General of the Department of Overseas Trade, Sir Edward Crowe, C.M.G., recently suggested at a gathering of Staffordshire manufacturers and business men that the manufacture of steel doors, chairs, furniture and roofs might prove a useful development for an area like South Staffordshire. He described what was going on in America, and on the Continent in this direction, and threw out this hint of a possible new industry. While steel manufacturers in the Midlands appreciate the suggestion and are quite able and ready to manufacture steel articles of any kind for which there is a commercially paying demand, they point out that Germany and the United States have gone very far in advance of this country in the use of steel for new and wider purposes. They would like to see some evidences of a potential demand for these classes of goods by the British public when they would assuredly set to work to manufacture not only steel doors and roofs, but steel articles of every description for which there was a call.

Engineering.

In the Midlands and Staffordshire area general engineering business, while still subdued, has a slightly better appearance. Preparations are being made for putting in hand a good many schemes of development that have been taking shape during recent months. It is hoped that progress will be accelerated by the cheapening of money and the lowering of the prices of some metals and minerals. As the engineering industry is one of the largest consumers of iron and steel, the effect of the improvement should be felt on the Birmingham market in the near future. Some branches of engineering in this district, however, such as the edge tool trade, are experiencing a prolonged period of depression. The ironfoundries are slightly better off, and the sheet metal and hollow-ware trades tend to advance in some small degree.

Automobile Industry.

The automobile engineering industry in Coventry, Birmingham, and Wolverhampton shows some improvement on recent weeks, and the coming of the spring holidays is bringing a demand for cars alike heavy and light, and agents are in some cases now pressing for deliveries. Notwithstanding this fact, business is far below normal for the time of the year, and unemployment in the trade continues. Hardly any of the manufacturing works are producing to full capacity. The general uncertainty which has of late upset car makers' plans is said to have ruined the trade for this year. It is impossible, makers now assert, to make up the ground so far lost this season. Producers of accessories for the industry are similarly affected. They welcome the recent slight betterment of the position.

Rolling Stock.

Midland rolling stock establishments continue regularly employed, but new orders are not coming in as rapidly as work is being turned out, so that the outlook is becoming less assured. Few orders of any magnitude are being received just now from the home railways, a large proportion of their requirements being met out of their own resources. Export orders are also unsatisfactory, neither the Argentine, India, nor South Africa calling for the quantities of rolling stock which they used to take from Midland manufacturers. Last year's large orders for freight trucks for the Argentine are now nearing completion, and they are not, unfortunately, being anything like fully replaced by further contracts. While for the industry generally the immediate outlook is not very hopeful, there are quite reasonable prospects that before the fulfilment of old contracts materially reduces the volume of work in the shops, some substantial reinforcements will be forthcoming. The Crown Agents are making inquiries which, it is hoped, will lead to very acceptable business.

Midland Trade with Australia.

While the raising of the Australian tariff and the attitude recently taken up by the Australian banks as to the financing of imports is hitting some sections of Midland manufacturers very hard, the efforts being made to consolidate the present range of industries in that country and to enter into the manufacture of many goods not previously attempted is benefiting other local industries. Steel trap makers in the Wednesfield area of Staffordshire report an almost complete falling off of orders from this source. The making of traps, animal and vermin, constitutes a not inconsiderable trade, and Australia up to now has provided quite a large market. Makers of electrical goods throughout the Midlands are also adversely affected, while many manufacturers complain that large consignments of goods are being held up, instructions having been received to defer shipment. On the other hand, orders are arriving from Australia in Birmingham and district for various descriptions of industrial equipment. Firms who specialise in chain-making machinery and machinery for the manufacture of lifting tackle and other handling and transport appliances are responding to the demand for quick delivery. The tariff is, of course, framed so as to facilitate admission of imports essential to the country's industrial development as a necessary preliminary to ultimate independence.

Pig Iron.

Midland smelters of pig iron maintain their firm position as to prices declining to be influenced by changes in the position in other districts. They assert that the artificial maintenance of prices in Cleveland left such a disparity that there is no fear of encroachment on the zones of the Central Producers' Association, save in one or two not very important districts. At their monthly meeting last week the situation was reviewed, but it was decided to turn a deaf ear to the clamour of consumers who have been pressing for price concessions, and adhere, at any rate for the time being, to their declared intention of maintaining the present level of prices until the end of April. Most of Midland blast-furnaces still have substantial contracts on their books, and despite the fact that new business is small and irregular they profess no anxiety as to the immediate future. Users of pig iron now know where they stand. They have undoubted evidence of the intention of furnacemen to keep a tight hand on the rein. They have had control of the market now for a twelve-month, and they do not intend to give the whip hand to the consumer if firmness can prevent it. So far users of pig iron continue to restrict their purchases to small parcels urgently required, but freer buying in the near future is anticipated, at least by blast-furnacemen. Consumers demands do not show any sign of expansion, either in the case of foundry or forge grades, but stocks at the works are not large. A number of contracts are now almost due for renewal and negotiations as to terms are in progress between the respective parties. Quotations on 'Change in Birmingham this week are on the official basis :—Northamptonshire : Forge, £3 11s.; No. 1 foundry, £3 18s.; No. 2, £3 17s.; No. 3, £3 15s.; No. 4, £3 14s. Derbyshire : Forge, £3 14s. 6d.; No. 1 foundry, £4 1s. 6d.; No. 2, £4 0s. 6d.; No. 3, £3 18s. 6d.; No. 4, £3 17s. 6d.—delivered at stations in the Black Country.

Finished Iron.

Finished iron, apart from best grade bars, is in poor request, and in the Staffordshire finished iron trade regular work is possible only at the marked bar mills. In the merchant and common bar branches the general state of the industry is very unsatisfactory. Mills are having to work short time, owing to the scarcity of orders. Internal competition in the Crown bar department and foreign competition in the nut and bolt bar trade is such as to leave Staffordshire makers little chance of success. They maintain their quotations because they see no prospect of securing orders if they lower them, at least unless they are prepared to do business at a big loss. Ironmasters who have converted their plant for the re-rolling of foreign steel continue fairly active, but even in this department there has been some falling off in business during recent weeks. Rollers are able to compete, however, fairly successfully against the big steel mills, and they have been able up to the present to maintain selling prices at £8 upwards. Wrought iron tube strip sells at £11 2s. 6d., but values are just now rather shaky. Users are pressing for better terms and the strip mills being none too well situated for business, millowners have some difficulty in upholding the present price level.

Steel.

There is no variation in the steel trade in this area from the conditions existing a week ago. Demand for finished steel is poor all round, and specifications do not come up to expectations. There is some talk of an improvement in the call for steel on behalf of the automobile engineering firms, but, if true, it is as yet insufficiently strong to make itself felt. Plate mills are moderately engaged, and are able to secure £9 12s. 6d. per ton for boiler plates from district firms who are operating regularly. In other classes of steel a moderate trade is being done. The re-rolling business lacks vitality, but so far there has been no downward movement in prices. For small bars rolled from foreign billets, £8 is quoted as a minimum, and the finished bar from the Continent is to be had at £6 9s. English billets are unchanged. For a good order £6 2s. 6d. is accepted, but a number of sellers, well placed, want more.

Galvanised Sheets.

There is no change on the week in trading conditions in the galvanised sheet industry. Galvanised corrugated sheets of 24 gauge continue on the basis of £11 17s. 6d. f.o.b. for export, while other gauges are quoted as a week ago. Overseas business continues below normal ; local mills have been able to keep going with the home market.

Tin-plate.

In the tin-plate trade there is a quickened inquiry in this district for wasters, and some sizes are commanding rather more than schedule prices. The stringency is attributed less to development of consumption than to the restricted working of the mills.

Steel Scrap.

Steel scrap prices remain weak, and they are generally the subject of bargaining between merchant and consumer. Warehouses are in most cases already full, and there is no disposition to add to stocks. Birmingham merchants this week report conditions as "duller than ever."

Cannock Chase Coal Profits.

For the seventh consecutive month, the Cannock Chase coal industry has made a profit on the coal raised in the area. The figures just issued show a profit of 1s. 9·21d. per ton. Based on the proceeds of the industry for the months of December, January and February, the capacity of the coalowners to pay wages is 40·02 per cent., but this is the highest point reached for some months, and it is anticipated that next month the wages will mount above the 42 per cent. minimum guaranteed by the employers under the 1926 agreement. During April miners' wages in this coalfield will be 42 per cent. above the 1911 wage basis, which will give stallmen a minimum rate of 9s. 4d. per day.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

"Machinists" at Crewe.

STATEMENTS as to the new policy adopted by the board of directors of the London, Midland and Scottish Railway Company with respect to apprentice fitters employed at the Crewe locomotive shops have been current this week. Since the grouping of the companies fitters have received their notices when they have reached the age of twenty-three, but the new policy is to re-engage as many fitters as possible when they come out of their time in order to fill the vacancies of those employees who are retiring under the age limit of 65. The practical effect of the change is that the men will be classed as "machinists" at a wage which will be lower to the extent of from 9s. to 12s. a week. It is understood that the scheme has been well received by the men, and a number who had already received their notices undertook at the beginning of the present week to resume work on the reduced status.

Overhaul of the "Royal Scot."

For the second time since they were built three years ago, the last of the fifty "Royal Scot" type of engine has just passed through the Crewe works of the London, Midland and Scottish Railway Company for overhaul. A start on the work of dismantling and reassembling these engines was made last autumn, and a number of departments at the Crewe works have been working three shifts to ensure that they should be running again in time for the Easter traffic, the boiler shop being particularly affected. The Easter stoppage at the Crewe shops, it is learned, will extend from Thursday noon—April 17th—until the following Tuesday morning.

Surplus Stations.

The recent acquisition by the London, Midland and Scottish Railway Company of motor bus services in West Lancashire areas will, it is understood, shortly result in the closing of four small stations in the Fylde district —Lea-road and Salwick, between Preston and Kirkham, and Wrea Green and Moss Side, between Kirkham and Lytham.

Obituary.

Mr. James William Slack, late managing director of the Richmond Gas Stove and Meter Company, and a director of Radiation, Ltd., died last Saturday at Grappenhall, near Warrington, at the age of 73. After serving with the Ashton-under-Lyne and Tunbridge Wells gas companies, Mr. Slack came to Warrington twenty-six years ago as secretary to the Richmond Gas Stove Company and later was appointed managing director.

Non-ferrous Metals.

Varying degrees of reaction have been noticeable in the market for non-ferrous metals during the past week, following upon the general recovery previously reported. This tendency has been the more pronounced in the case of tin. A fair amount of buying has been going on in this section of the market, and up to last week-end values had been maintained at very little below the highest point touched during the previous week. In the opening days of the present week, however, a setback has been experienced and about half the previous gain has been wiped out, the loss on balance being in the neighbourhood of £4 per ton. In spite of a rather restricted business both in standard and refined descriptions of copper, the movement of prices has been much less important than in tin, spot metal being cheaper to the extent of about half-a-crown a ton, with forward positions dearer by 15s. At the moment of writing foreign lead is a shilling or two lower than it was a week ago, but English metal has been maintained and a fairly extensive business in this section of the market has been experienced. The improvement in spelter has been short-lived and quotations are now back below the level of a fortnight ago. A moderate demand for the metal has been experienced during the week.

Iron and Steel.

Almost throughout the iron and steel markets dull conditions continue to prevail. Quite apart from the position at the consuming end, there is now a very definite lack of confidence in the stability of foundry iron prices, and in anticipation of an early downward revision of quotations by Midland ironmasters Lancashire users are placing orders for no bigger quantities than are essential. Until April is out and prospects are clearer than they are at present inactivity is likely to continue. For delivery

to users in the Manchester price zone, Stafford and Derbyshire pig irons are both at 77s. per ton, with North-East Coast brands at about 80s., Scotch at from 94s. to 95s., and West Coast hematite at about 92s. per ton, also delivered to users in the Manchester area. There has been no appreciable improvement in the rate at which constructional steel against old contracts is moving into consumption, whilst new business is virtually a dead letter on this market. Locomotive building firms, however, are specifying for fair quantities and a moderate tonnage has been bought during the past week. In most other respects the demand from the point of view of bulk business has been quiet. Boiler plates are quoted here at about £9 17s. 6d. per ton, tank plates at £8 17s. 6d., large bars at £9 7s. 6d., small re-rolled varieties at from £8 to £8 2s. 6d., according to quantity, sections at £8 7s. 6d. and joists at £8 10s. There has been no alteration in the prices quoted on the Lancashire market by continental mills, but buying interest locally remains very poor and most of the small orders that have been placed this week have been for material in second hands at shaded rates.

Manchester Association of Engineers.

The Manchester Association of Engineers concluded its seventy-fourth session on March 28th, when Mr. G. E. Windeler, M.I. Mech. E., was elected president for the ensuing year in succession to Mr. James A. Robertson, M.I. Mech. E. The new president is a well-known Manchester consulting engineer, who has had wide experience in connection with heavy-oil and other internal combustion engines. The meeting was one of the series of joint meetings which are arranged each year by certain engineering institutions in Manchester, and on this occasion the guests were the members of the North-Western Centre of the Institution of Electrical Engineers. A paper on "Marine Diesel Installations with Particular Reference to Auxiliaries," was read by Mr. James Calderwood, of Messrs. Sulzer Bros.

The Engineers' Club.

Considering the depression which exists in the staple industries of Lancashire at the present time, the annual report of the Committee of the Engineers' Club for the past year, which was presented at a meeting of the members last week, must be considered extremely satisfactory. The membership has been well maintained and the financial position is thoroughly sound. One of the most useful features of the Club is the service which it is rendering to all the leading technical societies in providing comfortable rooms for their meetings and dinners. The Club is being regularly used by the Institutions of Mechanical, Electrical and Automobile Engineers, as well as by the Manchester Association of Engineers and the Manchester Metallurgical Society. In the early days of the Club a Trust Fund was formed by the generosity of some of its members with the object of assisting the sons of deceased members to obtain education and training in the engineering, architectural and surveying professions. Up to date there have been no calls upon this fund and there is now available a sum of nearly £400 for the purposes mentioned. With the further object of extending its sphere of utility, the Club has now thrown open its doors to a limited number of apprentices and students with degrees who are eligible for membership as Associates at a much reduced subscription until they attain the age of 25 years. As Associate Members these young engineers enjoy all the privileges which are afforded by a high-class club, except that of voting at meetings. At the annual general meeting Sir Benjamin Longbottom was re-elected president for the present year, and the Hon. Treasurer—Mr. J. Owden O'Brien—and Hon. Secretary—Mr. H. Richardson—were also re-elected.

BARROW-IN-FURNESS.

Hematite.

With the restarting of the rail departments at Barrow, there is a reduction of the amount of iron on the open market. In no part of the district are there any heavy stocks, and, in fact, at some works there is scarcely any. There is a slight improvement in the general tone and orders held will keep producers engaged until the end of May. Prices are still keen, leaving little, if any, margin, and there is a tendency for the demand for better qualities of iron of stated analysis to increase, especially on overseas account. Business with America is maintained and continental trade is steady. The Dominions have also been purchasers of iron of special quality. The iron ore trade, both as regards native and foreign, is about the same as far as the local demand is concerned, but outside business is inclined to be quieter. The steel market is only moderate. Competition for contracts is keen as regards prices. Barrow has restarted and is sure of a run for a short period, but fresh orders for railway material would be welcome. The hoop trade is steady and the mills are well fixed for contracts, mostly on overseas account.

SHEFFIELD.

(From our own Correspondent.)

Waiting for the Budget.

There was nothing very cheerful about the tone of the speeches delivered at the annual meeting of the Sheffield Chamber of Commerce. In one or two cases, it was complained that remarks recently made by public men had taken too optimistic a view, and that to talk about the turn of the tide was concealing the seriousness of the situation and doing harm. Certainly, there is no improvement to report, taking things as a whole. Reports of quietude and shortage of orders come from many quarters, and only a small minority of firms are enjoying real activity. At the same time, there is reason to believe that when the Budget proposals have been announced, a good deal of business which is now being held back will be released. Consumers of steel and steel products in the home market are buying very sparingly, and stocks must have run low. There is, however, also a serious falling off in overseas business. Trade is bad in other countries besides our own, and such a state of things, even in competing markets, has a reaction which is felt here.

Departments Reviewed.

The production of basic steel is still maintained at a good level, but existing orders are being gradually worked off, and their places are not being fully taken by new bookings. There is danger that some furnaces may have to be shut down unless a buying movement develops before long. This remark does not apply to the North Lincolnshire district, however. The works there are not only continuing to run full time, but facilities for production are being increased. The acid side of the Sheffield heavy trade is poor, but some good orders for heavy steel forgings have just been booked. The great plants devoted to the production of railway steel could do with a lot more work, though they are rather better employed on axles and tires than has been the case of late. During the past week John Brown and Co. have booked an order for 308 locomotive tires, of the approximate value of £2000, for the South African Railways. This order has been placed in Sheffield by the German firm which secured the contract for the engines themselves. The special departments of the steel trade continue in much the same state as previously reported. Stainless and non-corrodible steels are in large demand for a variety of purposes. Much valuable work is being done in cold rolled steel and strip, though this business shows some falling off from its peak level. There is also a decline in the demands of the automobile makers. This is one of the trades in which the Chancellor of the Exchequer's Budget speech is being awaited with intense interest. The saw trade is depressed, and the same remark is true of files. For the latter there has been a shrinking demand ever since Christmas. Owing to the competition of grinding and other abrasive methods, the call for files has apparently ceased to expand. Such business as is on offer is keenly sought, and complaints of price cutting are heard.

Hollow Forged Drums.

One of the best pieces of news that Sheffield has heard during the past week relates to orders for hollow forged seamless drums, the production of which is a comparatively new branch of its industry, in which two firms specialise. John Brown and Co. have received orders for a total of twenty-five of these drums, required for Stirling high-pressure boilers in connection with the super-power station at Thornhill of the Yorkshire Electric Power Company, and the extension of the Sheffield Corporation boiler installation. The total value of these orders exceeds £25,000. Still larger orders have been booked by the English Steel Corporation, for execution at the Vickers Works, Sheffield, and in this case the work has been secured from abroad, in the face of intensive continental competition. No fewer than seventy-four forged steel boiler drums are to be made by this firm, together with large supplies of forgings and electrical machinery. The orders will take several months to complete, and will involve the production of some 5000 tons of ingots. Some of these hollow forged drums are of huge dimensions. The English Steel Corporation has just completed an order for twenty-four of them, the largest of which were 44ft. long, 5ft. in diameter and 4¼in. thick.

A Lincoln Development.

Lincoln will await with interest the development of a remark made by the chairman of Robey and Co., one of the city's well-known engineering firms, at the annual meeting last week. The company was able to show better results for 1929 than for the previous year, but this was due to improved methods of production rather than to better prices being obtained for its products. He said that, with a view to enlarging the scope of the company's activities, negotiations were well advanced whereby an important further branch of manufacture, well within the capacity of the company, would be shortly undertaken. He described the prospects of the company as entirely hopeful.

Railway Progress.

Both the L.N.E. and the L.M.S. railway companies have on hand important schemes of development in this district. The L.N.E.R. Company has decided upon the doubling of its main line from York to Northallerton, beginning at the north side of the bridge which carries the line over the river Ouse at Poppleton, and finishing at the junction south of Northallerton Station. The plans are all prepared, and it is expected that the contracts will be let shortly. The expenditure involved will run to about £500,000. A number of stations will be extended, and some of them will have to be demolished entirely in order to provide room for the laying of two new tracks. Included in the scheme is provision for the installation of colour light signalling. The new development on the L.M.S. Railway relates to the widening of the main line at Mirfield, to enable improvement to be made in communication between Yorkshire and Lancashire towns. Two new main lines are to be laid over a distance of nearly a mile, and the scheme, which will take about fifteen months to complete, also involves the widening of a viaduct over the river Calder and the construction of a large group of sidings on the east side of Mirfield Station.

Cutlery and Plate.

With few exceptions, the turnover of the firms engaged in the cutlery and plate trades shows a falling off for the first quarter of this year, as compared with last year. Both the home and export markets are affected. Trade with Australia is particularly down. In view of that country's financial situation, the people have been appealed to to reduce their purchases of imported goods, and their smaller call for cutlery and plate shows that they are complying with the request. All through the export trade the demand for low-priced goods is growing. The colonial trade in stainless spoons and forks is expanding, but this is at the expense of the plated variety. There are a few valuable contracts on hand for best quality goods for steamship equipment. The scissors branch is fairly active, and sales during the past six months have shown an increase. On the export side quantities are greater, but values have declined, showing that overseas buyers are taking more of the cheaper goods than formerly. Firms which supply the cutlery trade with stainless steel blades ready forged or goffed, announce a new and higher scale of charges, as from April 1st. This step has been brought about by a rise in the cost of the raw material, the makers of which have agreed to work to a higher scale of prices for stainless steel suitable for cutlery.

Lincolnshire Water.

Two interesting schemes of water development are afoot in Lincolnshire. One, which is on a large scale, affects the Holland district and a part of Lindsey, and is estimated to cost no less than £470,000. Messrs. Alexander Binnie, Son and Deacon, engineers, have prepared an exhaustive report on the subject, which they have submitted to the Regional Water Committee. They criticise the Boston supply from Revesley, stating that it cannot be relied upon to give more than 300,000 gallons per day. They express the opinion that proposed increased storage works at Revesley should not be constructed, but that instead the water from Bourne, which is abundant and excellent, should be used in conjunction with the Boston supply for the whole area. The scheme provides for a supply of 1,000,000 gallons daily to the Spalding sugar beet factory during the twelve weeks it is in operation. It will involve the laying of 150 miles of distributing pipes and the erection of water towers and boosting plants at a cost of £320,000; while the Bourne, Spalding and Boston waterworks would have to be taken over at the cost of a further £150,000. Expert advice which has been given to the Brigg Urban Council shows that, contrary to what was thought, there is a sufficient supply of water at the source of the present supply, at St. Helen's, Wrawby. The engineer finds, however, that considerable waste is taking place owing to the reservoir leaking, and it is suggested that a water tower should be erected in place of the reservoir in order to increase the storage capacity.

Derby Electricity.

Mr. J. H. Thomas, the Lord Privy Seal, who is one of the Members for Derby, last week formally opened large extensions which have been carried out at the Derby Borough electricity station, at a cost of £140,000. The station is a selected one under the scheme of the Electricity Commissioners for Central England, and it was on this account that the extensions were decided upon. They include boiler plant, generating plant, and switchgear of the latest types. An increased capacity of 60 per cent. has been obtained through the addition of a 20,000-kW turbo-alternator and two new boilers.

NORTH OF ENGLAND.

(From our own Correspondent.)

Coal Miners' Wages Deadlock.

Northumberland coalowners and miners have failed to reach agreement on the respective claims by the miners for an increase in the minimum percentage and by the owners for a reduction in the subsistence wage. In view of the failure to agree the claims will now be submitted to the independent chairman, Mr. J. M. Bailey. On every point the parties found themselves diametrically opposed. The miners' contention was that the two last ascertainments had shown that such had been the recovery of the Northumberland coal trade, that more than the present minimum percentage above basis rates was payable to the men, especially in view of the fact that Northumberland was paying the miners less than any other county. To this argument the owners replied that already they had shown a generous attitude by refraining from claiming the whole of the surplus above minimum percentages, which they were entitled to claim. Besides, they pointed out, there was no guarantee of the industry remaining in its present sound state. Indications, they urged, were that the trend was in the opposite direction—a result of the chariness of foreign buyers in placing contracts in view of the uncertainty about legislation. They based their claim for a lower subsistence wage on the fact that the Durham subsistence wage is lower than that of Northumberland.

April Wages Highest Since 1928.

Wages of pieceworkers in the Northumberland coal mines will be higher during April than they have been since January, 1928. This is the result of the ascertainment for the Northumberland coal industry for February, showing that the men's 87 per cent. of the proceeds would allow of 43·66 per cent. on the basis wage being paid. By a special concession the owners claim only half of the 3·66 above the 40 per cent. minimum towards wiping off the accumulated deficiency, so that pieceworkers' wages will be 41·83 per cent. above basis rates. During March wages were 41·38 per cent. above basis rates, but previously they had stood at the minimum of 40 per cent. since the present wages agreement was entered into in January, 1928. The figures mean even something bigger than higher wages. They mean that, in February, the Northumberland coal trade was in a better economic position than it has been for years. A slight improvement is also recorded in the ascertainment for the coal industry in Durham County. February's trading allows for the payment of 60·03 per cent. on basis wages, against 59·52 for the month of January. The minimum percentage for the county being 65 on the basis, the owners are required to make up the balance of 4·97 per cent.

Cleveland Iron Trade.

The Cleveland pig iron market presents a much brighter tone. The recent price cuts have been effective in stimulating business. Not only is there an improvement in the home demand, but also in the export inquiry. Better business has been done with Scotland, but in that area French iron is still competing. Second hands have less Cleveland iron to offer, and makers' quotations are firm. No. 1 foundry iron is 70s., No. 3 G.M.B. 67s. 6d., No. 4 foundry 66s. 6d., and No. 4 forge 66s.

Hematite Pig Iron.

East Coast hematite pig ion is slow of sale and heavy and increasing stocks are causing grave anxiety. Unless demand improves considerably in the near future, output will have to be curtailed by the damping down or blowing out of furnaces. Market rates continue to fall. Merchants are so keen to lighten their holdings that they readily accept offers at below figures generally named. Beyond a few small home sales for early delivery, there is little activity, cheap foreign hematite still keeping East Coast brands out of continental markets. Producers put market values on the basis of ordinary qualities at 76s., but customers state that they find no difficulty in placing orders at the equivalent of 75s. 6d.

Ironmaking Materials.

In the foreign ore trade sellers quote best Rubio at 21s. 6d. c.i.f. Tees, but consumers are still holding off the market. Sellers of blast-furnace coke ask 19s. 6d. for good medium qualities and supply is plentiful.

Manufactured Iron and Steel.

Manufactured iron and steel prices are steadily held. Producers of some descriptions of material are much in need of orders, but manufacturers of shipbuilding and bridge-building requisites and of necessities for railway construction have a lot of work to turn out.

Iron and Steel Exports.

Whilst pig iron production has had to be reduced, and in the case of hematite further curtailment is not improbable, it is a hopeful sign that the export trade is showing some resilience. The recent cut in Cleveland pig iron prices has certainly stimulated inquiry from abroad, and it would appear that the operations of the new Steel Export Association are having the desired effect in this particular branch of the trade. At all events, it is a fact that the March exports from the Cleveland district are the heaviest of any month since November last. Chiefly owing to better trade with Scotland, the pig iron shipments reached 20,208 tons in March, compared with 16,168 tons in February, and it is interesting to note that Denmark, which took 2942 tons, was the best foreign customer. Manufactured iron and steel shipments totalled 60,783 tons, a figure which has not been exceeded since October last. The February total was 49,423 tons. The improvement was in no small measure due to the heavy shipments to the Argentine, totalling 12,032 tons, which is the highest figure recorded since February, 1929.

The Coal Trade.

Whilst colliery fitters for every description of Northumberland and Durham steam coal are holding steadily for the full minimum prices, the contractors, who have ample stocks for disposal, are eagerly searching for an opening to clear their output and offer supplies at very substantial discount values. There is, however, little response, and the prospects for this month are not bright in spite of the cheap freight rates available, which allow some very low c.i.f. prices to be quoted at the various ports. Foreign coal is plentiful, and it is being offered at temptingly low prices for orders over the year. Best Northumberland steams, through fitters, are 14s. 6d. for large, and 11s. 6d. for small, but through other hands discounts of 6d. or more are indicated. For Durham steams the position is similar. Best qualities are quoted at 16s. 6d. and small at 13s. 6d., but definite offers are much below these figures. Owners are having to face a difficult forward position. Values of gas fuel are irregular. Best kinds are just nominal at 16s. 3d., secondary can be discounted at a nominal value of 14s. and best Wear grade coals are quoted at 16s. 9d.; but the undertone also favours buyers. The recent strength of the coking unscreened market has not been maintained. Good brands are obtainable readily at 14s. Bunker coal sellers also find an easier trend in the market, and whilst superior classes are holding steadily to 15s. to 15s. 6d., the good ordinary brands are obtainable at discounts at 14s. There is a good demand for gas coke, but prices show no recovery, and 21s. is the best value obtainable. Patent oven stocks are excessive and, with few buyers about, prices remain weak at 18s. Beehive and special grade foundry qualities are quoted unchanged at 26s. to 30s., but output depends entirely on the amount of definite business available.

Cleveland Miners' Wages Demand.

The Cleveland ironstone miners have decided to press upon the owners again the claim for revision of the whole of the base rates paid in and about the mines. The claim was turned down last summer by the owners, who contended that the industry was in a state of transition and that the time was inopportune. As consolation, the miners received an advance of 1¼ per cent., but no such solatium can be expected on this occasion. Indeed, the selling price of Cleveland pig iron has just been reduced, and whilst this may not affect wages during the current quarter, the ultimate consequence might be to reduce further the men's earnings.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding.

THE tonnage launched from Clyde yards during March showed a pronounced falling off compared with the same month last year, and the output this year to date now stands at forty-three vessels of 115,571 tons aggregate, compared with forty-two vessels of 147,611 tons aggregate for the same period last year. So far as this year has progressed, the returns show an output a little ahead of the average for the period, but the falling off in output compared with the past two years and the scarcity of new contracts of the liner and the cargo-liner types would make it appear that employment must suffer a gradual decrease unless the rate of new orders is accelerated. In the yards mainly interested in the types of vessels mentioned above, the majority of the berths are vacant, and those now occupied will be vacated in the near future. The Clyde output for March this year amounted to sixteen vessels of 36,477 tons. The largest vessel launched was the "New Zealand," twin-screw motor tanker, 11,000 tons, built by Barclay, Curle and Co., Ltd., for Erling H. Samuelsen, of Norway. The list included five cargo vessels ranging from 3000 to 5000 tons, and a number of pleasure craft, among the latter being a twin-screw yacht of 2200 tons for the Earl of Inchcape. Contracts announced during March included two cargo steamers of 9000 tons each, a motor tanker of 10,000 tons, and two motor tankers of 11,500 tons each.

Steel.

In most departments of the steel industry conditions are comparatively quiet, and as a rule some difficulty is experienced in keeping plants occupied with anything like regularity. Some works are more favourably placed than others, but as a rule specifications are short of requirements. Orders for heavy steel are somewhat disappointing. Steel sheets, too, are irregular, the light gauges being better off than the heavy descriptions. Galvanised sorts are fairly active, however. Conditions in the tube trade are slow to improve, especially as regards exports.

Scrap.

Business in scrap is comparatively dull. Consumers as a rule buy sparingly, and with supplies fairly plentiful prices are more or less unchanged at 69s. 3d. per ton for cast iron machinery, 65s. heavy steel, and 62s. 6d. per ton heavy basic.

Iron.

While producers of bar iron and re-rolled steel bars anticipate a seasonal improvement in trade, business meantime still runs on very quiet lines. Prices are unchanged with bar iron at £10 5s. home, £9 15s. export, and re-rolled steel bars at £7 12s. 6d. per ton, home or export. Pig iron is dull, only a small turnover being done about minimum rates.

Coal.

On the whole, the general outlook in the Scottish coal trade is not encouraging. Export demands are not increasing, and the collieries in the Lothians and Fifeshire are poorly placed in consequence. All descriptions of fuel, large and small alike, are in need of fresh orders, practically the only exception being Lanarkshire splints. Prices are not properly tested, but show a weaker tendency. Prompt export business is very patchy, and forward transactions are hardly mentioned. Aggregate shipments amounted to 241,837 tons, against 230,629 tons in the preceding week and 262,468 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade.

THERE can be no denying the fact that so far as steam coals are concerned there is comparatively little fresh inquiry in circulation, and the conditions all round are dull. But for the operation of the schedule of minimum prices there can be little doubt that values would sink to a lower level for most qualities; in fact, there is reason to believe that middlemen with contract coals on their hands, who, of course, are not bound by any arrangement respecting prices such as collery undertakings are, have in some instances sold coals at less than the minimum prices ruling. Unfortunately, there is still no indication of any improvement in the outlook for steam coals. A few new orders are, of course, coming along, but the competition for them is intense. Depressing, however, as the conditions are, there is the satisfaction that the weekly shipments are, taking all the circumstances into account, extraordinarily good. Despite the fact that reports are in circulation of contracts not being carried out, because foreign consumers decline to take the coals, there is no doubt that the bulk of the shipments being effected are on contracts entered into at the end of last year. According to the returns of the Great Western Railway Company, the total quantity of coals shipped last week at the ports under their control amounted to just over 593,000 tons, which compared with nearly 568,000 tons for the preceding week and with rather more than 525,000 tons for the corresponding period of last year. These figures apply to shipments both foreign and coastwise, and by no means can be considered unsatisfactory. It has also to be remembered that these shipments were carried out with the docks working far from fully. This is seen from the fact that at the end of last week the returns showed that there were thirty idle tipping appliances at the various docks and only three steamers were waiting to berth. The present week was started with the tonnage situation slightly better, as on Monday the number of tips idle was eighteen and three steamers were waiting. It is, however, to be feared that before the week is out collieries will be not so well supplied with ready steamers and will have great difficulty to avoid temporary stoppages. The docks and sidings are so full of loaded coals that recently the G.W.R. authorities have, in order to avoid congestion, had to stop coals coming to the docks until steamers are absolutely ready to load. At the present time there is no outstanding inquiry on the market, excepting, of course, the business of the Egyptian State Railways for 250,000 tons of locomotive coals for delivery over four months at Alexandria. For this tenders have to be at Cairo for decision on the 23rd inst. There is also an inquiry for one or two cargoes of best steam coals for Greece, but otherwise the demand lacks volume and feature.

Coal Find.

As the result of two years' boring operations for 600 yards at the Pontypool Colliery, belonging to the Eastern Valleys Black Vein Collieries, Ltd., a rich 7ft. section of the famous Black Vein has been struck. It is expected that in a year's time employment will be provided for 400 men, as against 70 at present.

Shipping.

Reference has on previous occasion been made to the state of shipping, which is passing through a time as critical, if not more so, than the coal industry. The position now is that records show that the total of British and foreign tonnage laid up is over 600 vessels, aggregating nearly 3½ million tons carrying capacity. A number of steamers which were taken out of service have been again put into commission. Owners have done this as soon as they have been able to secure business which would entail a smaller loss by trading than would be the case by keeping the vessels idle in dock. The remarkable point about the position is that, despite the exceptional amount of tonnage which is off the market, rates of freight, both outward and homeward, have not improved 3d. per ton in the past fortnight. Nothing like it can be remembered.

Anthracite.

Reports have been current of considerable contracts being entered into for the delivery of Russian anthracite coals to both Italy and Canada. More news is awaited regarding the competition of Russian anthracite in the Italian market, but so far as Canada is concerned, there are indications that shipments from South Wales this season will be even heavier than they were last year, when round about half a million tons were shipped. Steamers are now loading at Swansea, and more tonnage has been contracted for to load coals for Montreal and Quebec during this season than has ever been the case before.

Steel Props.

The annual report of the Cardiff Chamber of Commerce makes reference to the question of the substitution of steel props for timber in the South Wales collieries, and the fact that colliery managers are devoting considerable attention to it. This subject was dealt with in a paper by Mr. Robert James, delivered at a special meeting of the South Wales Institute of Engineers at Cardiff last week. The title of his address was "Steel Arches and Steel Props for Underground Support." In the course of his remarks he said that the possibility of replacing timber by steel as the main form of support in all mine workings opened up considerations of vital importance to the economic life of the country. Not only would a more general adoption of steel supports appear to offer the prospect of greater safety with reduction of working costs, but to an increasing extent would mean the replacement by steel produced in this country of timber now annually imported to the value of £5,035,000. An increase in the demand for steel for home consumption would at the present time be of inestimable value in assisting the heavy industries to recover a measure of their former prosperity. Progress in the use of steel props had been necessarily slow. The conditions underground were dependent on so many factors and were so variable that it was not surprising to find that the type of prop which gave satisfactory service under a particular method of working might be totally unsuitable under another set of conditions.

Tredegar's New Turbine.

Sir Edward Johnson Ferguson, one of the directors of the Tredegar Iron and Coal Company, put into operation on Monday the apparatus controlling a new 7500-kilowatt mixed-pressure turbo-generator. This new generator is necessitated by the development of the company's colliery undertakings in the lower part of the Tredegar Valley, viz., the Oakdale, Markham and the New Wyllie collieries. The generating set is designed to use 130,000 lb. of exhaust steam per hour. The plant has been supplied by British Brown, Boveri, Ltd., of London, and the accompanying condensing plant by W. H. Allen, Sons and Co., Ltd., of Bedford. The annual production of electrical power at Oakdale is something over 32,000,000 units per annum, and recently the power generated has been at the rate of over 36,000,000 units per annum.

Swansea Lock Scheme.

Referring to the question of a new lock entrance to the Swansea docks, Mr. C. S. Page, chief docks manager to the Great Western Railway Company, has since last week stated that the company is going on with the alternative entrance, and they hope to get what is called a late Bill through Parliament almost immediately. There can be no opposition so far as he can see. The work will be carried out in its entirety on the company's own property, and therefore will not interfere in any way with any private concerns. The new lock is to be of much the same dimensions as the existing lock, viz., 875ft. by 90ft., but it will be 3ft. deeper. A little deepening of the existing channel will be undertaken, and altogether work will be provided for a considerable number of men over two or three years. The cost will be approximately £1,000,000.

Current Business.

The tone of the steam coal market keeps extremely quiet. There is scarcely any section that can be described as active. Large coals are hardly saleable and smalls are in less demand. Sized coals are more irregular, and best dry nuts are now quoted at 22s. at the most. Coke is steady, but the inquiry for patent fuel is not quite so good, while pitwood is a shade steadier at 26s.

IN a report on the production and use of electric energy in Canada, the Dominion Bureau of Statistics states that the output of central electric stations during last year amounted to over 18,014 million kilowatt-hours. The large stations, which generate between 97 and 98 per cent. of the total, reported 17,625,900,059 kilowatt-hours for 1929, or an increase of 10·6 per cent. over the 1928 output and almost double the output for 1924.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
(1) Native	19/6 to 21/–
(1) Spanish	21/6 to 23/–
N.E. Coast—	
Native	18/– to 21/–
Foreign (c.i.f.)	21/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	4 1 0	—
No. 1 Foundry	4 0 6	—
No. 3 Foundry	3 18 0	—
N.E. Coast—		
Hematite Mixed Nos.	3 15 6	3 15 6
No. 1	3 16 0	3 16 0
Cleveland—		
No. 1	3 10 0	3 10 0
Silicious Iron	3 10 0	3 10 0
No. 3 G.M.B.	3 7 6	3 7 6
No. 4 Foundry	3 6 6	3 6 6
No. 4 Forge	3 6 0	3 6 0
Mottled	3 5 6	3 5 6
White	3 5 6	3 5 6
Midlands—		
(3) Staffs.—	(*Delivered to Station.*)	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 15 6	—
„ „ Foundry	3 19 6	—
(3) Northampton		
Foundry No. 3	3 15 0	—
Forge	3 11 0	—
(1) Derbyshire—		
No. 3 Foundry	3 18 6	—
Forge	3 14 6	—
(3) Lincolnshire—		
No. 3 Foundry	3 13 6	—
No. 4 Forge	3 9 6	—
Basic	—	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 9 6 (*a*) / 4 11 6 (*b*) / 4 15 0 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. Coast—		
Iron Rivets	11 10 0	—
Common Bars	10 15 0	—
Best Bars	11 5 0	—
Double Best Bars	11 15 0	—
Treble Best Bars	12 5 0	—
Lancs.—		
Crown Bars	10 15 0	—
Second Quality Bars	9 15 0	—
Hoops	13 0 0	—
S. Yorks.—		
Crown Bars	11 0 0	—
Best Bars	11 10 0	—
Hoops	12 0 0	—
Midlands—		
Crown Bars	10 0 0 to 10 7 6	—
Marked Bars (Staffs.)	12 10 0	—
Nut and Bolt Bars	9 2 6 to 9 7 6	—
Gas Tube Strip	11 2 6	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates (Marine)	10 10 0	10 10 0
„ „ (Land)	10 0 0	10 0 0
Ship Plates, ½in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	9 0 0	8 15 0
Sheets (Gal. Cor. 24 B.G.)	12 15 0	12 5 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 10 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	8 2 6	—
Soft Billets	6 17 6	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 10 0	—
Light Rails	8 15 0 to 9 0 0	—
Billets	6 15 0 to 9 10 0	—
Manchester—		
Bars (Round)	9 7 6	—
„ (Small Round)	8 0 0 to 8 2 6	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	9 17 6	—
Sheffield—		
Siemens Acid Billets	9 10 0 (basis)	—
Hard Basic	9 2 6 and 9 12 6	—
Intermediate Basic	7 12 6 and 8 2 6	—
Soft Basic	6 10 0	—
Hoops	9 15 0 to 10 0 0	—
Soft Wire Rods	8 0 0	—
Midlands—		
Small Rolled Bars	8 0 0 to 8 15 0	—
Billets and Sheet Bars	6 2 6 to 6 12 6	—
Galv. Sheets, f.o.b. L'pool	11 17 6	—
Sheets (30 W.G.)	16 7 6	—
Angles	8 7 6	—
Joists	8 10 0	—
Tees	9 7 6	—
Bridge and Tank Plates	8 17 6	—
Boiler Plates	9 12 6	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	18/3 to 18/6
Block Tin (cash)	166 7 6
„ (three months)	168 2 6
Copper (cash)	70 5 0
„ (three months)	68 13 9
Spanish Lead (cash)	18 16 3
„ „ (three months)	18 16 3
Spelter (cash)	18 2 6
„ (three months)	18 13 9
Manchester—	
Copper, Best Selected Ingots	77 5 0
„ Electrolytic	84 2 6
„ Strong Sheets	110 0 0
„ Tubes (Basis Price), lb.	0 1 3
Brass Tubes (Basis Price), lb.	0 1 1
„ Condenser, lb.	0 1 3
Lead, English	20 12 6
„ Foreign	19 0 0
Spelter	19 0 0
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/4½ per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 7 6	7/–
„ „ 6 p.c. to 8 p.c.	£22 10 0	7/–
„ „ 8 p.c. to 10 p.c.	£22 0 0	7/–
„ „ Specially refined		
„ „ Max. 2 p.c. carbon	£33 10 0	10/–
„ „ „ 1 p.c. carbon	£38 0 0	13/6
„ „ „ 0·70 p.c. carbon	£40 10 0	15/–
„ „ carbon free	11d. per lb.	
Metallic Chromium	2/7 per lb.	
Ferro Manganese (per ton)	£13 15 0 for home; £13 10 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£11 10 0 scale 5/– per unit	
„ „ 75 p.c.	£19 0 0 scale 7/– per unit	
„ Vanadium	12/9 per lb.	
„ Molybdenum	4/2 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£170 to £175	
Ferro Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(*Prices not stable.*)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	13/6
„ „ Ell	14/9
„ „ Splint	16/6 to 18/–
„ „ Trebles	12/–
„ „ Doubles	11/–
„ „ Singles	11/–
Ayrshire—	
(f.o.b. Ports)—Steam	13/6
„ „ Jewel	17/–
„ „ Trebles	12/6
Fifeshire—	
f.o.b. Methil or Burntisland—Steam	11/6 to 12/9
Screened Navigation	16/6
Trebles	12/–
Doubles	11/6
Singles	11/–
Lothians—	
(f.o.b. Leith)—Best Steam	12/6
Secondary Steam	12/3
Trebles	11/6
Doubles	11/3
Singles	11/–

ENGLAND.

	Inland.
(8) N.W. Coast—	
Steams	21/6 to 23/–
Household	38/– to 51/–
Coke	22/– to 22/6
Northumberland—	
Best Steams	14/3 to 14/6
Second Steams	13/– to 13/6
Steam Smalls	11/–
Unscreened	13/–
Household	25/– to 37/–
Durham—	
Best Gas	16/–
Second	13/9 to 14/3
Household	25/– to 37/–
Foundry Coke	26/– to 29/–
Sheffield—	
Best Hand-picked Branch	26/6 to 28/–
Derbyshire Best Bright House	21/– to 23/–
Best House Coal	20/6 to 21/6
Screened House Coal	18/6 to 20/–
„ „ Nuts	16/6 to 18/–
Yorkshire Hards	15/6 to 17/–
Derbyshire Hards	15/6 to 17/–
Rough Slacks	9/– to 10/–
Nutty Slacks	7/6 to 8/6
Smalls	3/– to 5/–
Blast-furnace Coke (Inland)	17/– on rail at ovens
Furnace and Foundry Coke (Export), f.o.b.	19/6 to 20/–

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	20/–
Second Smokeless Large	18/9 to 19/9
Best Dry Large	18/6 to 19/–
Ordinary Dry Large	17/9 to 18/6
Best Black Vein Large	18/3 to 18/6
Western Valley Large	18/– to 18/3
Best Eastern Valley Large	18/– to 18/3
Ordinary Eastern Valley Large	17/9 to 18/–
Best Steam Smalls	13/6 to 14/–
Ordinary Smalls	12/9 to 13/3
Washed Nuts	17/– to 21/–
No. 3 Rhondda Large	20/6 to 21/–
„ „ Smalls	15/6 to 16/–
No. 2 „ Large	17/– to 17/3
„ „ Through	16/– to 16/6
„ „ Smalls	14/– to 14/3
Foundry Coke (Export)	32/6 to 37/–
Furnace Coke (Export)	27/– to 28/–
Patent Fuel	22/– to 22/6
Pitwood (ex ship)	26/– to 26/3
Swansea—	
Anthracite Coals:	
Best Big Vein Large	35/– to 37/6
Seconds	28/– to 32/–
Red Vein	23/6 to 27/6
Machine-made Cobbles	42/6 to 45/–
Nuts	43/– to 46/–
Beans	25/– to 27/6
Peas	19/6 to 20/–
Breaker Duff	10/– to 10/6
Rubbly Culm	11/– to 11/9
Steam Coals:	
Large	20/– to 21/–
Seconds	18/6 to 19/6
Smalls	12/6 to 13/6
Cargo Through	15/6 to 16/6

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate: Joists (minimum), 12/6; Ordinary Ship, Bridge, and Tank Plates and Sections, 10/– if home consumers confine purchases from associated British Steel Makers.

French Engineering Notes.

(From our Correspondent in Paris.)

Protection from Floods.

THE recent floods in the South of France have left so strong an impression upon the public mind, particularly in reviving memories of the still greater disaster in 1875 which arose from the same cause, that all possible means of preventing similar destruction of life and property in the future are being investigated. About afforestation practically everything has been said, and the Government has voted considerable sums for the reconstruction of woods and forests, but while this remedy may produce some practical result, it can hardly be supposed that it will absorb or prevent the letting loose of huge volumes of water that accumulate on high impermeable plateaux during long periods of heavy rains. Therefore, some engineers who are responsible for river maintenance have come to the conclusion that the only rational solution is to allow the rivers perfect freedom to carry away all the water that flows into them. All floods are due to the fact that rivers are choked and strangled by bridges, embankments and obstructions of different kinds, and by allowing the water to flow freely past bridges and restoring to the rivers their natural beds, there will be no difficulty in carrying all the flood water rapidly away to the sea. The towns that suffered most during the recent floods lie along the banks of the Agout, Garonne and other rivers. Inundations in Paris have been caused by the obstructions in the Seine, and following the removal of many of them the danger has been greatly diminished. The principle upon which flood protection should be carried out in the future is, therefore, to allow the rivers full freedom to carry away the water. This plan implies paying attention to the design of bridges and the removal of all unnecessary obstacles, the worst of which is the narrowing of the river in its passage through towns. It is not always possible to compensate for this reduction of width by maintaining a sufficient depth.

Rolling Stock Improvements.

In its annual report the Paris–Orleans Railway Company deals with the work of improving its rolling stock and equipment that was carried out last year. While most of that improvement relates to an extension of the electrified system, reference is made to the results obtained with the "Pacific" type of locomotive adapted to use superheated steam. These results were so encouraging that a second locomotive for using highly superheated steam has been put into service. The type is declared to be more efficient and more economical and to allow of the full power being maintained for longer periods. It has been decided to continue fitting locomotives with screens to prevent the smoke from being blown down on to the cab and to equip another batch of locomotives with automatic repetition signals, together with indicators recording the driver's manœuvres. By the end of last year about 8000 wagons and trucks had been adapted for coupling up to goods trains with continuous brakes and work had been started upon a first lot of 4000 wagons to be fitted with the complete brakes.

Electrical Engineering.

The report presented to the Syndicat Général de la Construction Electrique upon the electrical engineering industry last year shows that the situation was far less satisfactory than had been supposed. As it deals largely with the question of tariffs there may be a reason for the somewhat pessimistic tone of the report. It insists upon the maintenance of the existing minimum tariff and upon the right of Parliament to vote whatever measures may be necessary in the interests of the industry. While the exports of electrical machinery from Germany and the United States have rapidly increased, those of France have remained almost stationary, and as the imports into this country were larger, there was, for the first time since 1914, an unfavourable balance of trade, so far as concerned, at least, the value of the machinery. This result is attributed to the high production costs which are constantly increasing, principally on account of increased wages. Here, again, an appeal is made for greater economy in public expenditure and a reduction of the charges that weigh upon industry. The electrical engineering trades have suffered severely for years past from the supply of material from Germany on account of reparations, but this disadvantage has now been alleviated by the considerable reduction of such imports under the new arrangement, and there will be a steady diminution each year until the supplies cease altogether.

Motor Cars.

The Tariff Committee is now discussing the terms of the Bill which is to be introduced into the Chamber of Deputies shortly in order to replace the existing *ad valorem* duty of 45 per cent. upon foreign motor cars by a duty on weight so adjusted that it will represent approximately the real ratio of duty to value. Naturally, the automobile makers' associations are agitating in favour of getting as high a duty as possible. They are helped in this agitation by the condition of the industry, which is bad; so bad, indeed, that makers regard the situation with grave concern. They fear more particularly the competition of American cars, which is becoming increasingly keen on account of the apparent saturation of the market in the United States. While the Committee is discussing the specific amount of duty to be imposed, the United States has raised to an absolutely prohibitive level the duties on certain goods which will ruin an important French industry. This fact may be a coincidence, but it has made a strong impression on the French, who see that if an attempt is made to exclude foreign cars there may be complications in other ways. That consideration seems to have influenced the Tariff Committee, for it has rejected the higher duty which it was proposed to incorporate in the Bill and has accepted a more reasonable tariff, and if its scheme is finally adopted for debate in the Chamber it will, no doubt, give rise to a discussion that may afford some clear indication of what is really the Government's tariff policy.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

325,287. November 17th, 1928.—BRUSHES FOR USE IN DYNAMO-ELECTRIC MACHINES, The Morgan Crucible Company, Ltd., and John Edward Grant, both of Battersea Works, Church-road, London, S.W. 11.

The object of this invention is to provide an improved compound brush, *i.e.*, a brush in which the face which bears upon a commutator, is composed of portions of different materials. The brush shown is made in the usual rectangular form and has the usual contact face A produced by compressing copper powder mixed with graphite into a consolidated mass, and applying thereto heat treatment. A rectangular or other sectioned groove is then cut in the contact face in such a direction that a lubricating graphite piece inserted therein will sweep the whole of the

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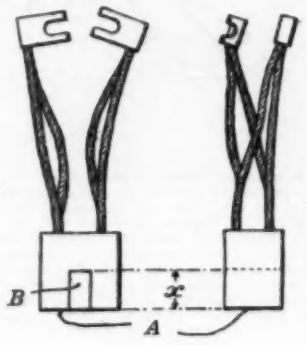

brush track, the depth x of the groove being approximately equal to the wearing depth of the brush. A prepared block of heat-treated consolidated graphite powder is made to substantially the same dimensions as the groove, and, after having been thirly painted with a solution of the material known under the registered trade mark "bakelite" or a similar solution, on those sides which will be in contact with the walls of the groove, is pressed into the groove so as to fill it as shown in the right-hand illustration. The brush is then stoved at a temperature suitable for the bakelite solution or other adhesive employed. The usual "pigtails" and connections are attached to or embedded in the top of the brush, and the compound contact bearing surface is made smooth and continuous.—*February 17th, 1930.*

SWITCHGEAR

295,634. August 7th, 1928.—SELECTIVE RELAYS FOR THE PROTECTION OF ELECTRIC CIRCUITS, Aktiengesellschaft Brown, Boveri and Cie., of Baden, Switzerland.

This specification describes a selective relay for alternating-current networks which is dependent on resistance and in which the relay mechanism is actuated by a separate member which responds to impedance, characterised by an arrangement which hinders the relay mechanism from being actuated at the normal responsive impedance as long as the voltage at the relay exceeds a predetermined fraction of the normal working voltage of the network. A represents the impedance-dependent member, which consists of an electro-magnet B fed from the current transformer C and an electro-magnet D fed from the voltage transformer E. The rotary armatures F and G of these electro-magnets are secured at different angles on the axis H. If the current in the

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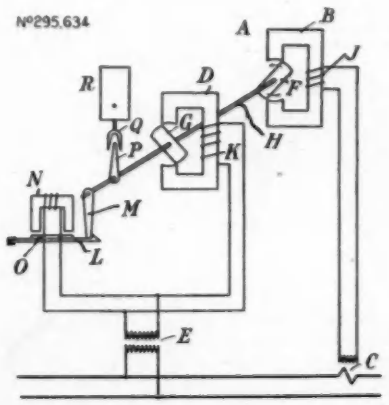

winding J increases or the voltage drops at the winding K the magnet armatures F and G try to turn with their axis in the direction of the arrow. Under normal conditions, however, an axial rotation of this kind is prevented by the pawl L, which retains the lever M secured on the axis H. If, however, the voltage drops to such an extent that the electro-magnet N releases its armature O and with it the pawl L, then the axis H can turn freely. In that case the lever P abuts against the fork Q of the time mechanism diagrammatically represented by R. This mechanism cuts out the faulty section of the line in a fixed period when a short-circuit current flows in a reverse direction in the faulty line or in a period dependent upon the impedance or resistance of the line from the relay to the fault when the short-circuit current flows in the normal direction in the line.—*February 7th, 1930.*

TRANSMISSION OF POWER.

325,248. September 12th, 1928.—OVERHEAD ELECTRICAL TRANSMISSION SYSTEMS, Arthur Hugh Seabrook, of Wyllyotts Manor, Potters Bar, Middlesex; and Alec Avis, of 318, Norton Way, Letchworth, Hertfordshire.

It is well known that in overhead transmission lines for electric power the conductor should be of high tensile strength and high electrical conductivity, but yet of small diameter or cross-sectional area in order to keep the mechanical stresses to which the conductors are subjected as low as possible. The object of this invention is to provide a conductor which is particularly suitable for use in overhead transmission lines for electric power and of which the diameter or cross-sectional area is small in comparison with the current-carrying capacity and/or mechanical strength to secure the benefit of decrease in the strength of support necessary or increase in the distance between the supports. According to the invention, a conductor for electricity comprises at least three wires, one or more of which constitute primarily a tension component, and one or more of which constitute primarily a conducting component, and which are so held together as to present a substantially continuous cross section. A conductor, according to the invention, may comprise metal wires of different conducting and tensile characteristics, the outer wires surrounding and protecting the central wires, whilst the sectional configuration of each of the wires is such that

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Fig. 1.

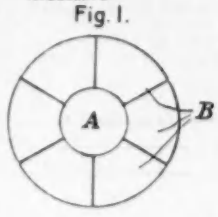
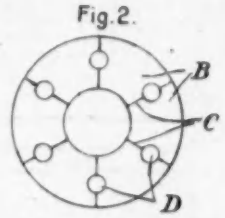


Fig. 2.



the conductor as a whole presents a substantially continuous cross section. Preferably the conductor comprises a number of wires of substantially segmental cross-sectional configuration, which are laid up or built together side by side around a central wire core of substantially circular cross-sectional configuration; in which case the substantially segmental wires may together constitute a tension component and the wire core a conducting component or *vice versâ*. The conductor illustrated by Fig. 1 is of very simple formation and is the preferred construction. It comprises a central circular wire A around which are laid up a number of segmental wires B. Fig. 2 shows a similar arrangement, but in this case the side or contiguous faces C of the segmental wires are formed with semi-circular grooves which are filled when the wires B are laid up or built together with circular wires D. Preferably the segmental or outer wires in each case constitute the tension component within which is disposed a central conducting component. In all cases the central wire core may comprise a single wire or a number of wires laid up or built together in a substantially circular formation. In a conductor according to the invention full advantage may be taken of the fact that some metals are of greater electrical conductivity when soft than when in a hard condition, by forming any of the wires of a conductor of such soft metals, even when the conductor is required to withstand great tensile stress.—*February 12th*, 1930.

FURNACES.

325,442. May 18th, 1929.—ASH-HANDLING PLANTS, *The Ash Company (London), Ltd.*, 63, *Lincoln's Inn-fields, London, W.C.* 2.

Ash and clinkers from the furnace above fall on to the rolls A and are crushed to a reasonable size. The rolls are cooled by jets

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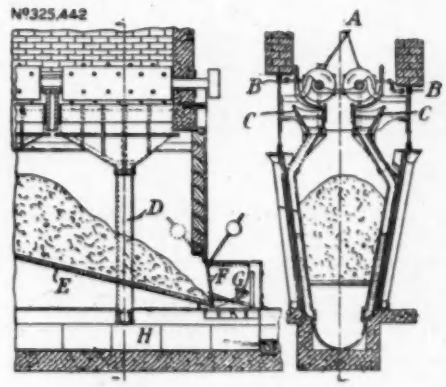

of water B B impinging on their outer faces. This water falls back on the outside, is collected in the troughs C C, and led away by the pipes D. The ash falls on to the sloping floor E and is periodically sluiced out through the door F by a jet of water G into the gully H.—*February 20th*, 1930.

TRAMWAYS AND RAILWAYS.

325,727. March 23rd, 1929.—COLLISION BUFFERS for RAILWAY VEHICLES, Metropolitan-Cammell Carriage, Wagon and Finance Company, Ltd.

In the preamble of this specification the inventors make the

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Fig. 1.

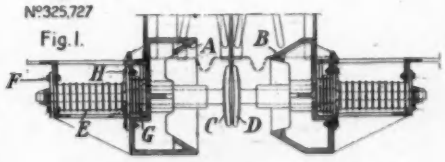
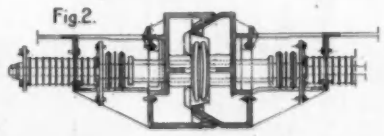


Fig. 2.



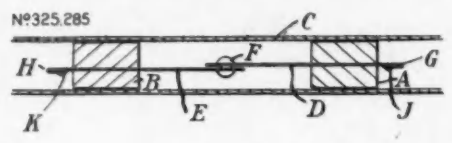
remarks that in collisions between trains of passenger vehicles the ordinary buffers are quite inadequate to absorb the momentum of the vehicles, and in the majority of collisions

adjacent vehicles are displaced either vertically, in which case one vehicle overrides and telescopes through the next, or laterally, in which case the vehicles are derailed and turned over and are then cut through by the following vehicles. In order to meet these conditions they provide the headstocks of adjacent vehicles with spigot and socket castings A and B, which normally are out of engagement, as shown in Fig. 1. There are also auxiliary buffers C and D, of which the rubber pads E take up normal shocks. In the event of the shock being excessive the bolts F are parted and the pads G then take up the load. Finally the bolts H may be broken and then the spigot socket A and B engage with one another to lock the two coaches in alignment, as shown in Fig. 2.—*February 27th*, 1930.

MISCELLANEOUS

325,285. November 17th, 1928.—Fusible Cut-outs for Electric Circuits, W. T. Henley's Telegraph Works Company, Ltd., of 11, Hoborn-viaduct, London, E.C. 1; and Percy Dunsheath, of the Research Laboratories of the Company, Gravesend, Kent.

An object of this invention is to provide a cut-out in which the duration of the arc and the temperature of the gases produced upon the blowing of the fuse have relatively low values. It has been found in practice that even with high current values the blowing of the fuse takes place practically silently and without the usual violent disruptive effects. Two movable pistons A and B are adapted to slide in a tube C. A strip of metal D passes through the piston A and may be secured to it in any suitable manner. Similarly a second strip of metal E passes through a hole in the piston B and is secured to this member. The strips D and E are made of high melting point metal. The



member F of low melting point metal and in the form of a rivet connects the two ends of the strips together and the ends G and H of the strips are bent over to form clips by means of which cables J and K can be connected electrically to the ends of the strips. When the connecting member F is subjected to an overload current it melts and the pressure generated in the space between the pistons A and B by the volatilisation of the metal forces these pistons apart and thus separates the inner ends of the two strips. The arc which is formed upon the fusing of the connecting member F is thus rapidly drawn out and extinguished. In order to allow for the rapid movements of the pistons the cables connected to the ends of the strips D and E are of comparatively small diameter, two or more cables being used if necessary to carry the current, thus preventing the stiffness of the cables from interfering with the outward movement of the pistons.—*February 17th*, 1930.

325,451. June 10th, 1929.—Improvements in Wood Screws, L. Grohmann, 275, Freiwaldauerstrasse, Würbenthal, Czecho-Slovakia.

The object of this invention is to improve wood screws by not only increasing the outer diameter of the thread gradually

towards the end of the screw, but also decreasing the core diameter of the screw gradually in the same direction. The screw thread is thus given a depth which gradually increases towards the end of the screw, whereby the screw is claimed to be better able to resist being torn out of the wood.—*February 20th*, 1930.

325,443. May 22nd, 1929.—Poppet Valves, T. Bowler, 396, Windsor-road East, North Vancouver, B.C.

In order to reduce the necessity for frequently grinding in the valves of internal combustion engines the inventor employs a loose valve seating. These seatings A A are held in place by a

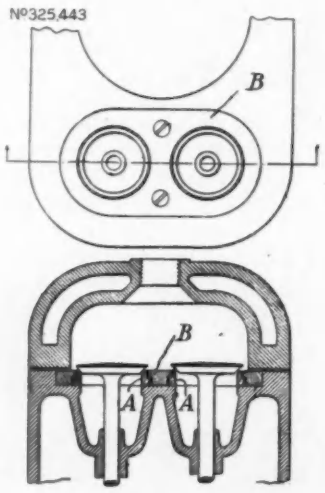
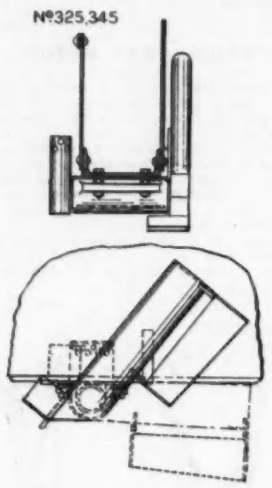


plate B, and are slightly smaller in diameter than the holes in the plate, so that they may adapt themselves to true alignment with the valves. It is explained that any slight leak which may occur between the seatings, the plate, and the main casting will become sealed with carbonised oil.—*February 20th*, 1930.

325,345. January 1st, 1929.—Gasholders, T. L. Bott, Birchfield, Donnington Wood, Wellington, Shropshire.

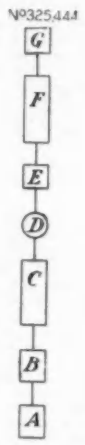
This invention relates to telescopic gasholders or gasometers, and its object is to prevent the escape of gas from the holder occurring owing to the gas "blowing" the seal in the cup of the holder. That is to say, as the gasholder descends into the tank water, the gas contained in the "dip" chamber becomes compressed considerably above the normal pressure in the holder. In large and heavy gasholders this greater pressure overcomes the seal made by the water in the usual cup, with the result that the gas escapes upwardly through the water in the cup to atmosphere, frequently depleting the amount of sealing water therein, with consequent loss and attendant danger. To overcome this defect the inventor pro-



vides means which will effectively equalise the pressure in the "dip" chamber of a descending lift of a gasholder with that in the body of the holder, thereby preventing the escape of gas by the "blowing" of the seal of the cup of the holder. The pressure equaliser consists of a hollow horizontally disposed member affixed to the underside of the cup. In that member there is rotatably mounted a plain, round, tubular connection or trunnion, which at each end terminates in a tube of convenient length, which at its free end is open, these tubes being arranged, more or less, at right angles to the trunnion. These tubes extend, the one into the "dip" chamber to constitute a "dip" tube, the other into the holder to constitute a "draining" tube, and to the "draining" tube there is affixed an air vessel or float.—*February 20th*, 1930.

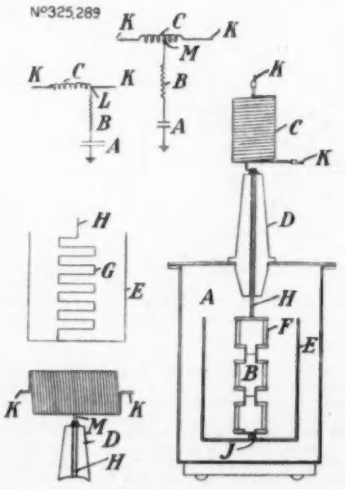
325,444. May 22nd, 1929.—The Treatment of Peat for the Production of a Fuel, D. W. Berlin, Rasunda, Sweden; and J. A. Brinck, Sölvesborg, Sweden.

The inventors propound a process for the treatment of peat, which is indicated diagrammatically in the drawing. The peat is dug by the machine A, which may be of the mechanical or hydraulic jet type. It is disintegrated and mixed with water at B, so that it is held in suspension. It is then subjected to a "wet carbonisation" process at C. The major part of the water is removed by a centrifuge D, followed by a filter press E. The resulting product is dried in a kiln F and is finally briquetted at G.—*February 20th*, 1930.



325,289. November 17th, 1928.—Lightning or Surge Arresters, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2, and Henry Stanley Holbrook, of 34, Lancaster-road, Rugby.

One object of this invention is to provide a device for the protection of electrical apparatus such as power transformers



adapted to operate on high-voltage systems having the neutral solidly earthed. The lightning or surge arrester comprises an earthed capacitor element A, a resistor element B and an inductance element C. The capacitor element A is constituted by an oil-filled tank having a high-voltage bushing D mounted on the cover of the tank and a conducting body E suspended within the tank from the bushing. The resistor element B is advantageously inside the tank and may be constituted either by a series of resistance rods F or by a bent wire strip or rod G, in which cases the resistor element may be supported from the bushing D by a rod H and the conducting body E suspended from the resistor element by a rod J. The inductance element C consists of a coil in series with the line K. Where the device is employed to protect a transformer the best results may be obtained when the resistor element B is connected to the junction L between the inductance element B and the line. Where the device is used for the protection of an overhead line the resistance element B may be connected to the mid-point M of the inductance element.—*February 17th*, 1930.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Institution of Chemical Engineers.—Hotel Victoria, Northumberland-avenue, London, W.C. 2. Annual dinner. 7 p.m. for 7.30 p.m.

Institution of Engineers-in-Charge.—Venetian Chamber, Holborn Restaurant, London, W.C. 1. Annual dinner. 6.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders.—Bolbec Hall, Newcastle-on-Tyne. "Ships' Electrical Deck Auxiliaries," by Mr. A. Read. 6 p.m.

SATURDAY, APRIL 5TH.

Institute of British Foundrymen: Lancashire Branch.—The College of Technology, Sackville-street, Manchester. "Some Aspects of Foundry Service to Engineers," by Messrs. E. J. L. Howard and H. Milner. 4 p.m.

Institution of Civil Engineers.—Students' visit to the works of the Ford Motor Company under construction at Dagenham.

MONDAY, APRIL 7TH.

Railway Club.—57, Fetter-lane, E.C. 4. "Railway Rambles with a Camera," by Mr. D. S. Barrie. 7.30 p.m.

Royal Society of Arts.—John-street, Adelphi, W.C. 2. Thomas Gray Lecture, "Aids to Navigation" (Lecture III.), by Commander F. G. Cooper. 8 p.m.

Society of Engineers.—Geological Society, Burlington House, W. "Rural Electrification and Electro Farming in Great Britain," illustrated by a film, by Mr. R. Borlase Matthews. 6 p.m.

TUESDAY, APRIL 8TH.

Institute of Marine Engineers.—The Minories, E.C. 3. "Recent Metallurgical Research in Relation to Marine Engineering," by Mr. S. L. Archbutt. 6.30 p.m.

Institution of Civil Engineers.—Great George-street, S.W. 1. "The Rebuilding of the Bassein Bridges on the Bombay, Baroda and Central India Railway," by Mr. B. B. Haskew; "The Reconstruction of the Attock Bridge Across the River Indus on the North-Western Railway, India," by Mr. W. T. Everall. 8 p.m.

Institution of Electrical Engineers: Scottish Centre.—The Royal Technical College, George-street, Glasgow, C. 1. "The Imperial Chemical Industries' (Ltd.) Steam and Electrical Power Plant at Billingham," by Messrs. H. A. Humphrey, D. M. Buist and J. W. Bansall. 7.30 p.m.

Institution of Petroleum Technologists.—Royal Society of Arts, John-street, Adelphi, W.C. 2. "Some Features of Modern Steam-operated Deep Hole Rotary Drilling Plant," by Mr. N. Matheson. 5.30 p.m.

Manchester Geological and Mining Society.—5, John Dalton-street, Manchester. "The Application of Geophysics to Mining, with Special Reference to the Location of Faults," by Captain H. Shaw. 4 p.m.

Television Society.—University College, Gower-street, W.C. 1. "Photo-electric Cells and their Applications," by Dr. T. H. Harrison. 8 p.m.

WEDNESDAY, APRIL 9TH.

Institution of Civil Engineers.—Great George-street, S.W. 1. "Recent Developments in Railway Permanent Way Practice, with Particular Reference to the Use of Metal Sleepers," by Mr. S. T. Dutton, M. Inst. C.E. 6 p.m.

THURSDAY, APRIL 10TH.

Institute of Marine Engineers: Junior Section.—The Minories, E.C. 3. A film display featuring "The Manufacture and Operation of the Babcock and Wilcox Water-tube Boiler, &c." 7 p.m.

Institute of Metals: London Local Section.—The rooms of the Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W. 1. Annual General Meeting. Open discussion on "The Solidification of Metals." 7.30 p.m.

Institute of Metals: Swansea Local Section.—In Thomas's Café, High-street. Annual General Meeting. 7 p.m.

Institution of Electrical Engineers.—Savoy-place, W.C. 2. "Surge Investigations on Overhead Line and Cable Systems," by Messrs. S. W. Melsom, A. N. Arman and W. Bibby. 6 p.m.

FRIDAY, APRIL 11TH.

Institute of Metals: Sheffield Local Section.—In the Non-ferrous Section of the Applied Science Department of the University, St. George's-square. Annual General Meeting. "Refractories and their Uses," by Mr. F. Russell. 7.30 p.m.

Institution of Chemical Engineers.—Municipal College of Technology, Sackville-street, Manchester. "The Fabrication of Acid-resisting Steel Plant," by Dr. W. H. Hatfield. 7 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. "Gas in Japan and the Far East," by Mr. W. T. Dunn. 7.30 p.m.

WEDNESDAY, APRIL 16TH.

Institution of Civil Engineers: Students' Section.—Great George-street, S.W. 1. "Weymouth: Bincleaves Firing Station; Repairing and Strengthening of Reinforced Concrete Pier," by Mr. P. A. Scott. 6.30 p.m.

WEDNESDAY, APRIL 30TH.

Machine Tool Trades Association.—King's Hall, Holborn Restaurant, High Holborn, W.C. 1. Annual dinner. 6.45 p.m. for 7.15 p.m.